



CHAPTER EIGHT

INTERSECTIONS AT-GRADE

Volume I

- Highway Design Guide –
National Standards

December 2004

Chapter Eight

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Chapter Eight

INTERSECTIONS AT-GRADE

8-1 INTERSECTION SIGHT DISTANCE (ISD)

8-1.01 No Traffic Control

Intersections between low-volume and low-speed roads/streets may have no traffic control. At these intersections, sufficient corner sight distance should be available to allow approaching vehicles to adjust speed to avoid a collision. Figure 8-1 provides the ISD criteria for intersections with no traffic control.

8-1.02 Yield Control

Yield control may exist, for example, at a freeway ramp terminal where the ramp traffic is provided a free-flowing right turn onto the minor road. At these locations, the driver on the freeway ramp needs sufficient sight distance to slow down to approximately 15 mph on the turning roadway and to determine if he/she should stop or proceed onto the minor road without a stop. The driver on the minor road needs sufficient sight distance to avoid a collision with the merging vehicle from the freeway ramp. These two objectives will determine the legs of the triangle to provide corner sight distance. Figure 8-2 illustrates sight distance at yield control locations and provides the criteria for application.

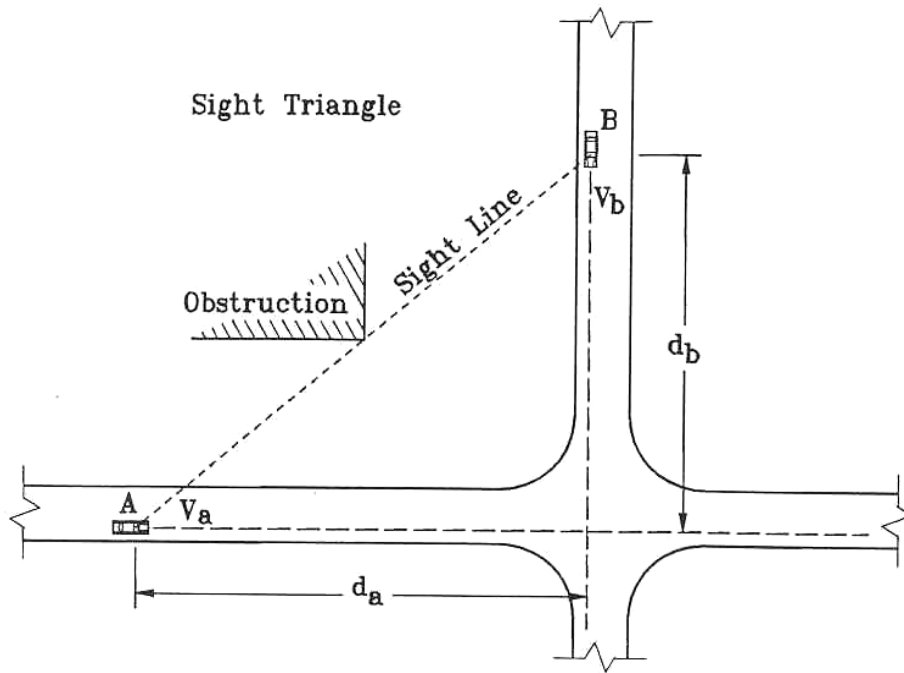
If insufficient sight distance is available for the operational characteristics of yield control, it may be appropriate to convert the yield into a stop control. The Traffic Engineering Division will make the final decision.

8-1.03 Stop Control

Figure 8-3 illustrates the application of the ISD criteria for stop-controlled intersections. In addition to the criteria in the Figure, the designer should consider the following:

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INTERSECTION SIGHT DISTANCE (ISD)



Design Speed (mph)	15	20	25	30	40	45	50	55	60
Sight Distance (ft)	70	90	115	140	195	220	245	285	325

Example

Given: No traffic control at intersection.

Design speed – 40 mph (Highway A)
30 mph (Highway B)

Problem: Determine legs of sight triangle.

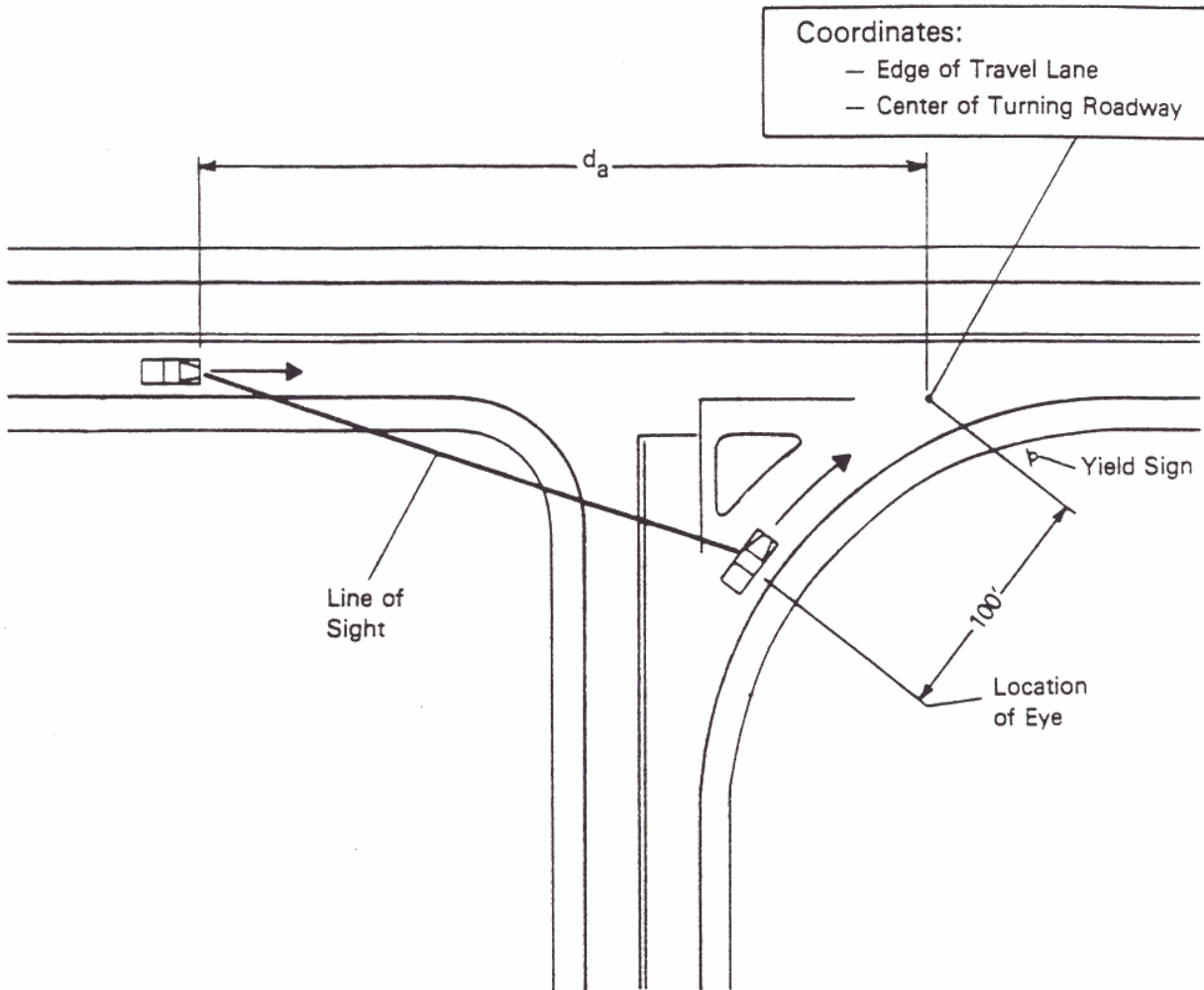
Solution: From above table – $d_a = 195$ ft
 $d_b = 140$ ft

**INTERSECTION SIGHT DISTANCE
(No Traffic Control)**

Figure 8-1

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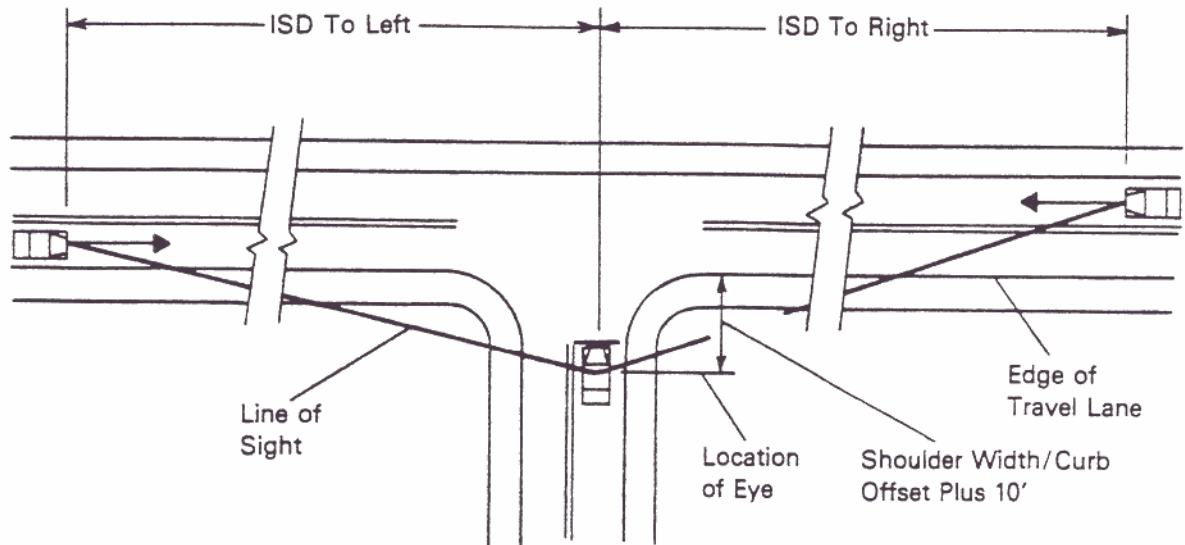
INTERSECTION SIGHT DISTANCE (ISD)



Design Speed (mph)	30	40	45	50	55	60
Sight Distance (d_a) (ft)	140	195	220	245	285	325

**INTERSECTION SIGHT DISTANCE
(Yield Control)**

Figure 8-2



Design Speed (mph)	25	30	35	45	50	55	60	65
Sight Distance (ft)	280	335	390	500	555	610	665	720

**INTERSECTION SIGHT DISTANCE
(Stop Control)**

Figure 8-3

1. Traffic Volumes. The ISD criteria are independent of mainline and turning volumes. At lower volume intersections, it may not be practical to meet these criteria.
2. Truck Volumes. The ISD criteria are based on operational characteristics of passenger cars. At intersections with higher truck volumes, it may be warranted to provide greater ISD values.
3. Multilane Facilities. The ISD model assumes a two-lane facility. On multilane facilities which do not have a median wide enough to store a stopped vehicle, the criteria in Figure 8-3 will also apply. On multilane facilities with a median wide enough to store a stopped vehicle, the designer should evaluate the ISD requirements in two steps:
 - a. With the vehicle stopped on the side road, the ISD will be checked to the left on the mainline.
 - b. With the vehicle stopped in the median, the ISD will be checked to the right on the mainline.
4. Height of Eye/Object. The height of eye is 3.5 feet, and the height of object (an approaching passenger car) is 3.5 feet.

8-1.04 Signal Control

Where right-turn-on-red is allowed, the designer should check to determine if the ISD criteria in Figure 8-3 (to the left) is available for right-turning vehicles. If not, this may be justification for prohibiting the maneuver at the intersection. The designer should notify the Traffic Engineering Division or the responsible municipality of the situation.

8-2 TURNING RADII DESIGN

Each intersection will be designed according to each of the parameters described in the following sections.

8-2.01 Design Vehicle Selection

Figure 8-4 through 8-9 provide the turning paths for the typical design vehicles (WB-62, WB-50, WB-40, BUS, SU and P, WB-67). The WB-67 will typically be the selected design vehicle for determining the appropriate turning radii design. In urban areas, use the largest turning radius that can be practically used at the intersection.

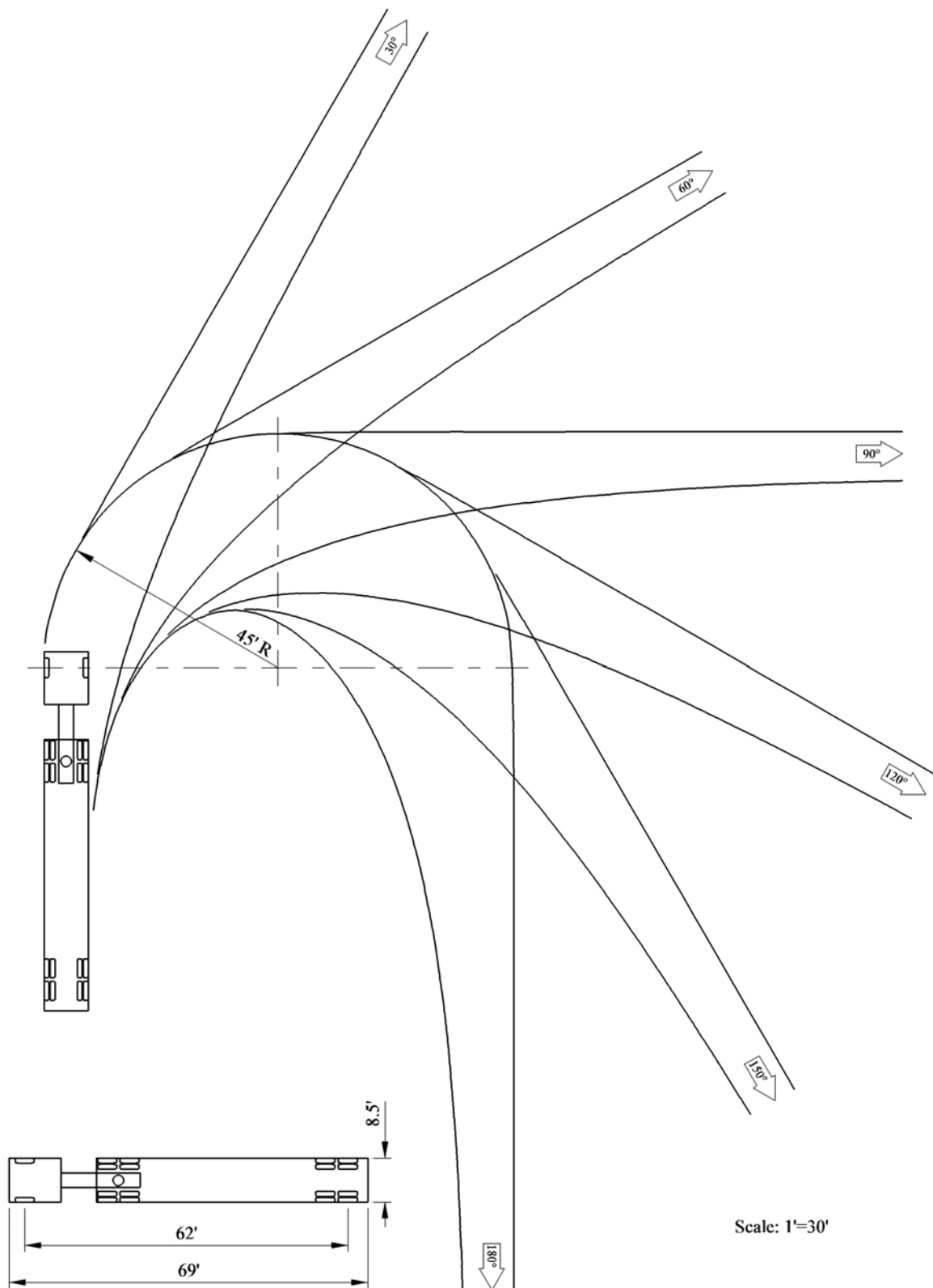
Pursuant to the requirements of the 1982 Surface Transportation Assistance Act (STAA), the State of Maine has established its federally designated routes for use by the WB-67 design vehicle. The State has also established its application for the "reasonable access" provision of the 1982 STAA. The Federally designated routes are:

1. Maine Interstate System,
2. Scarborough Connector from I-295 in South Portland to U.S. Route 1 in South Portland,
3. South Portland Spur from I-95 in South Portland to U.S. Route 1 in South Portland,
4. Maine Turnpike from I-95 in Portland to I-95 at West Gardner,
5. U.S. Route 1 from I-95 at Brunswick to the Congress Street/U.S. Route 1 interchange in Bath, and
6. U.S. Route 1 from I-95 at Houlton to the Canadian border at Fort Kent.

For the purpose of reasonable access, the WB-67 has general permission to operate on the entire State Aid and State Highway System.

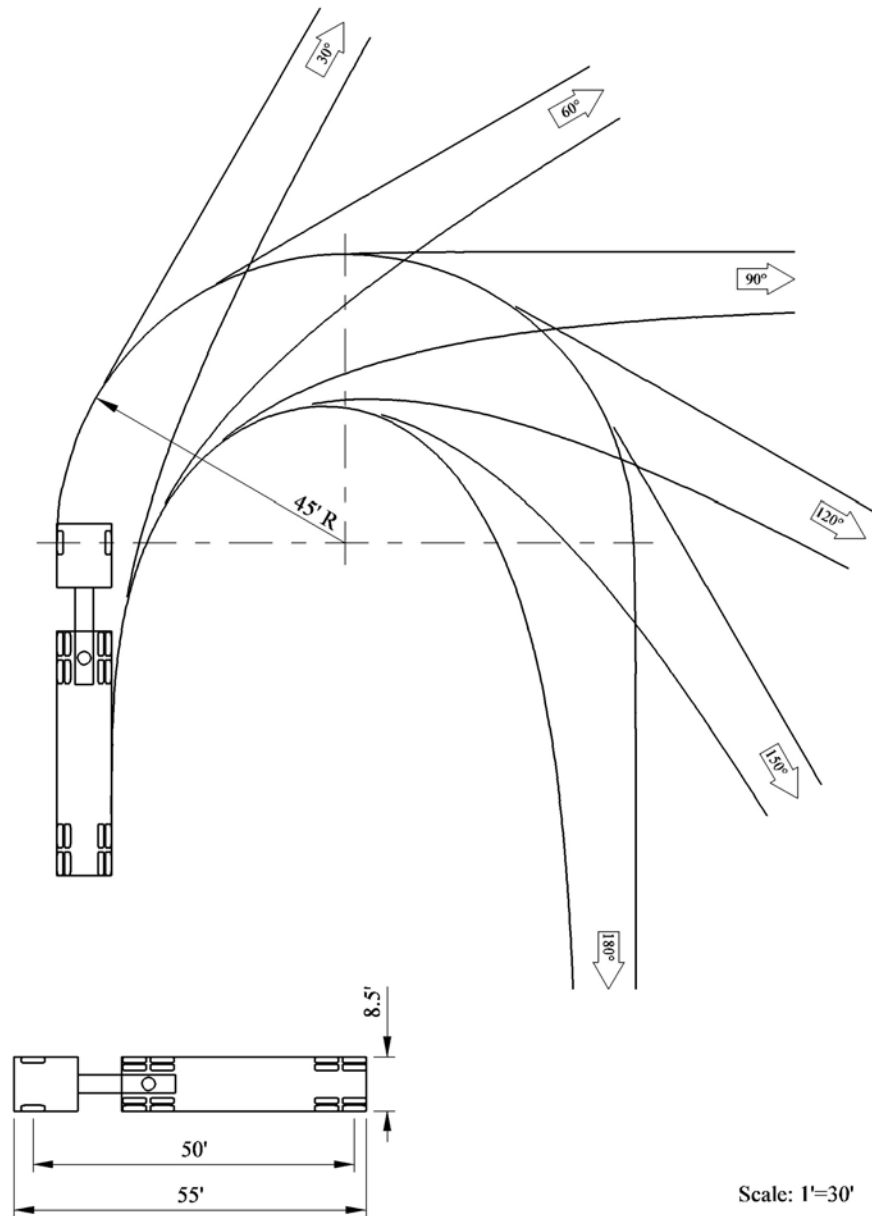
8-2.02 Inside Clearance

The design vehicle will be assumed to make the right turn while the inner wheels maintain approximately a 2-foot clearance from the pavement edge or curb line throughout the turn.



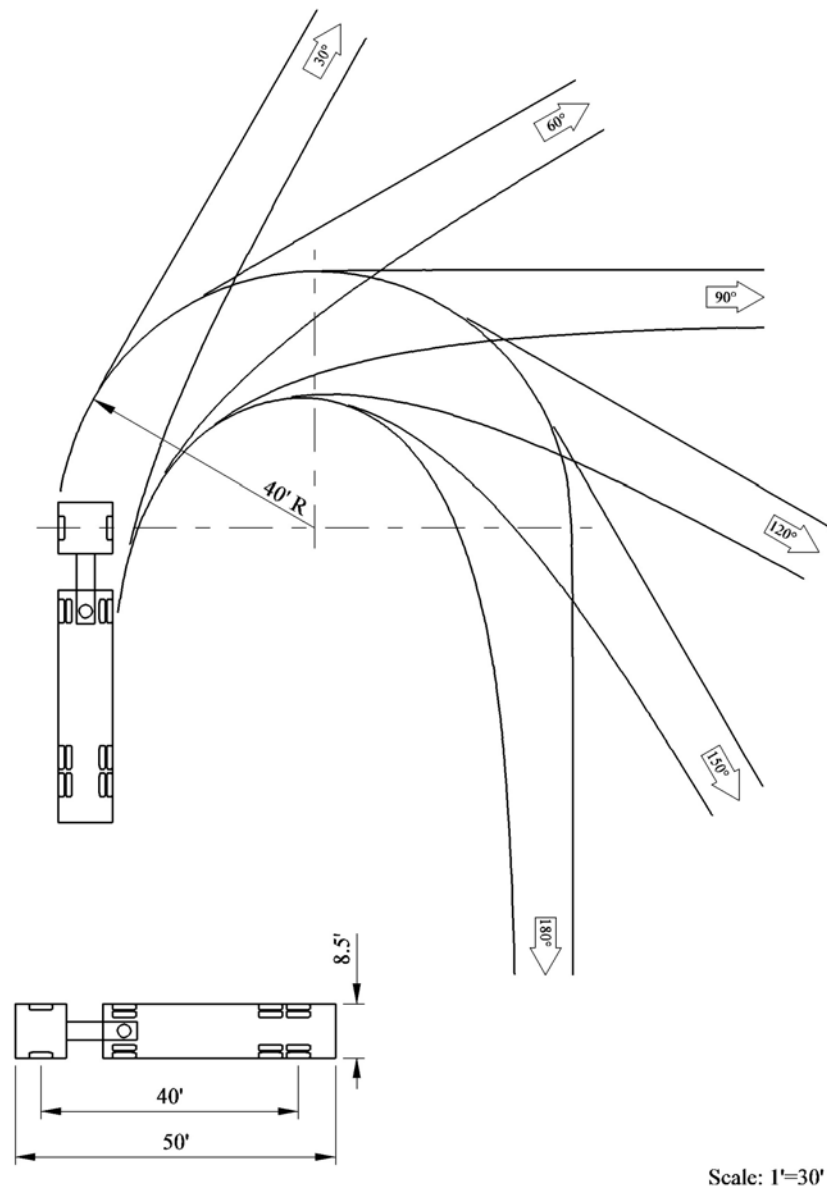
MINIMUM TURNING PATH FOR WB-62 DESIGN VEHICLE

Figure 8-4



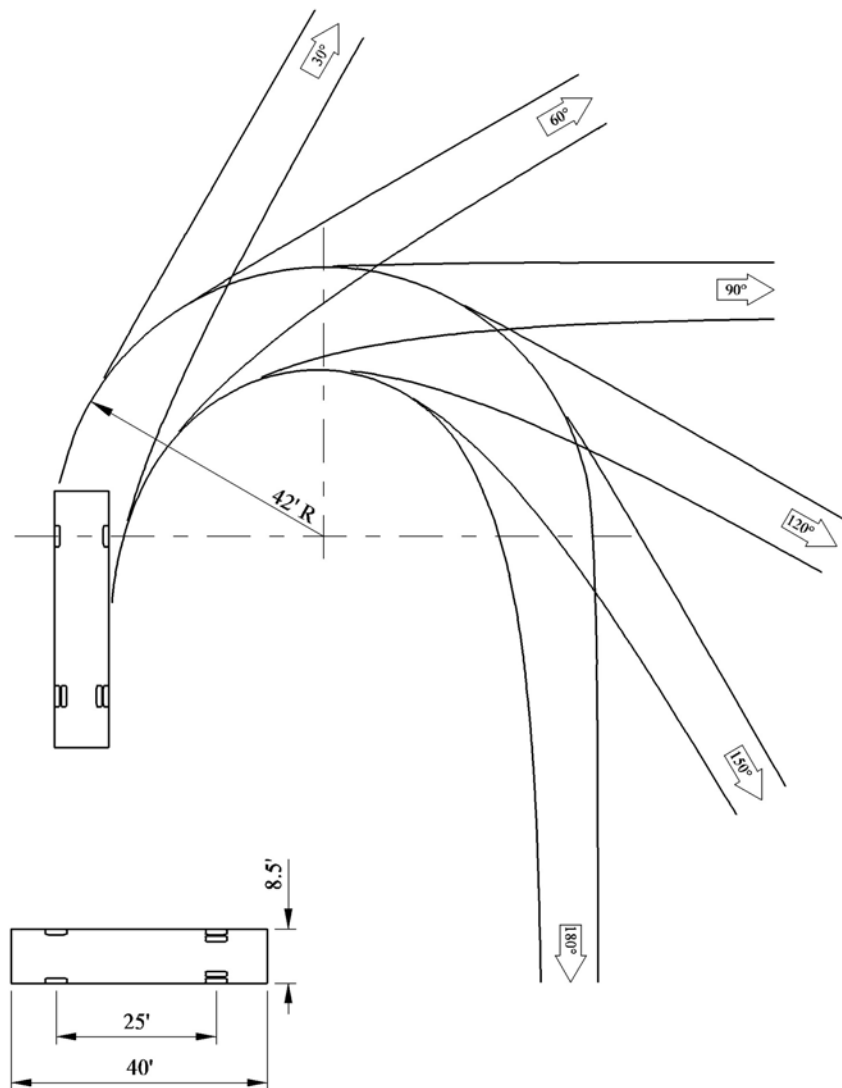
MINIMUM TURNING PATH FOR WB-50 DESIGN VEHICLE

Figure 8-5



MINIMUM TURNING PATH FOR WB-40 DESIGN VEHICLE

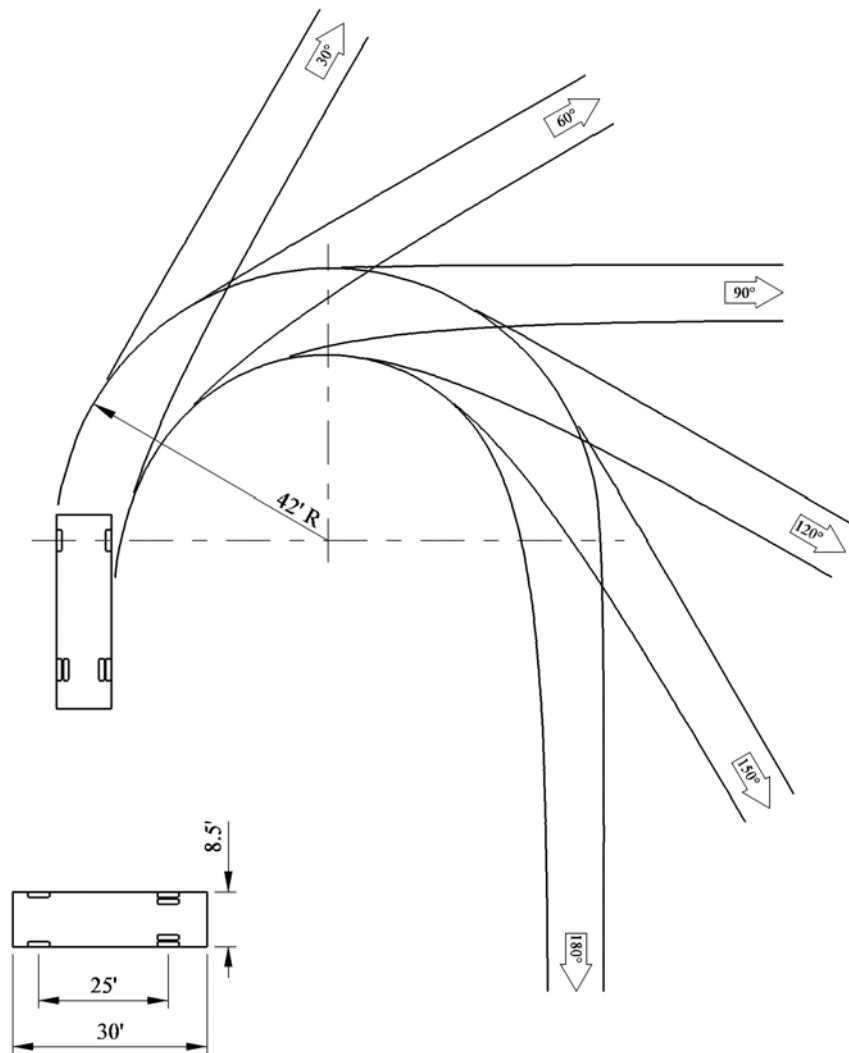
Figure 8-6



Scale: 1'=30'

MINIMUM TURNING PATH FOR BUS DESIGN VEHICLE

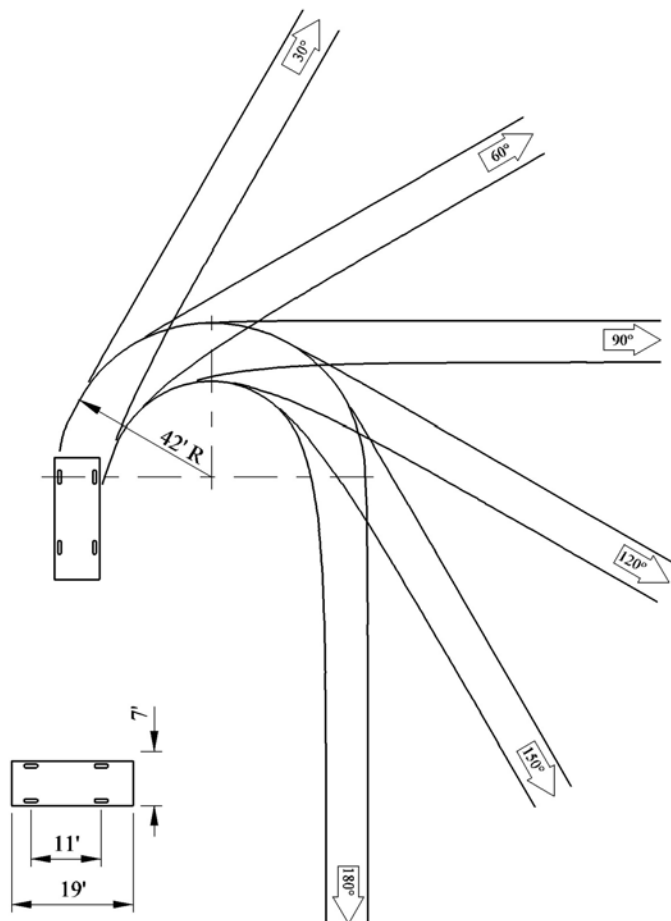
Figure 8-7



Scale: 1"=30'

MINIMUM TURNING PATH FOR SU DESIGN VEHICLE

Figure 8-8



Scale: 1'=30'

MINIMUM TURNING PATH FOR P DESIGN VEHICLE

Figure 8-9

8-2.03 Encroachment

The following will apply to vehicular encroachment into other lanes:

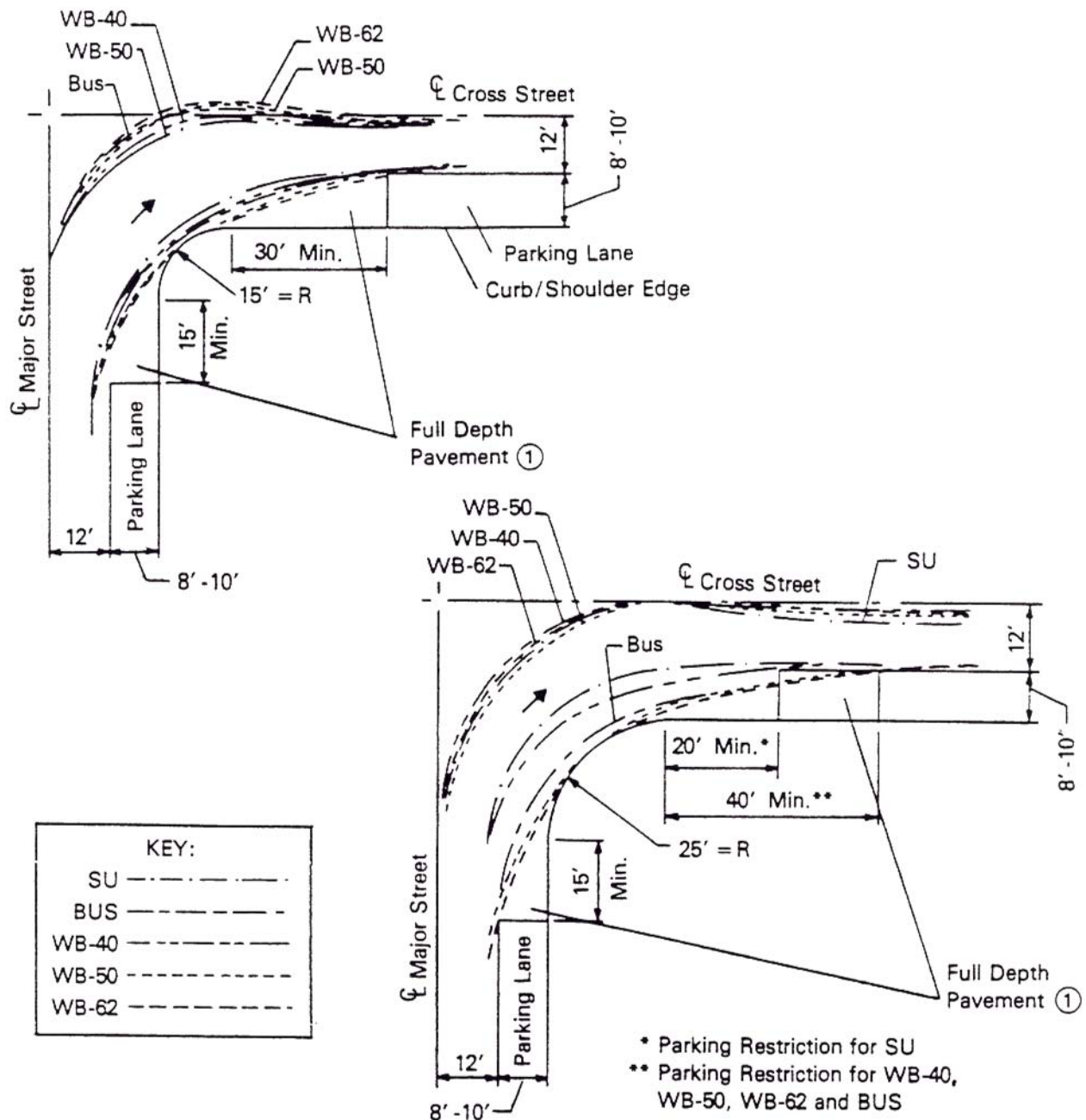
1. **Initial Position.** Before the turn is made, the design vehicle (WB-67) is assumed to be in the lane which will require the most restrictive right-turn maneuver.
2. **Road From Which Turn Made.** The turning vehicle (WB-67) will not encroach onto the adjacent lane on the road from which the turn is made.
3. **Road Onto Which Turn Made.** For turns onto arterial and collector facilities, the turning vehicle (WB-67) cannot encroach into opposing lanes of traffic. If there are two or more lanes of traffic moving in the same direction, it is acceptable for the turning vehicle to occupy both travel lanes. However, if practical, the turning vehicle will be able to make the turn while remaining entirely in the right through lane.

For turns onto local facilities, the WB-67 should physically be able to make the turn within the available paved area without impacting curbs, parked vehicles, appurtenances (e.g., utility poles) or any other obstacles. An exception to this will be freeway ramp intersections with local facilities. The WB-67 should be able to make the turn from the freeway ramp to the local facility without encroaching into opposing lanes of traffic.

4. **Other Factors.** When determining the geometric design elements of the intersection (e.g., lane widths), the designer should evaluate many factors. These include turning volumes, through volumes, typical speeds approaching the intersections and the type of traffic control at the intersection. The designer must also consider the construction and right-of-way impacts for meeting the encroachment recommendations. For example, if these impacts are significant and if through and/or turning volumes are relatively low, the designer may decide to accept an encroachment for the design vehicle (WB-67) which exceeds the recommendations in Numbers 2 & 3 above.

8-2.04 Parking Lanes/Shoulders

At many intersections, parking lanes and/or shoulders will be available on one or both approach legs, and this additional roadway width may be carried through the intersection. This will greatly ease the turning problems for large vehicles at intersections with small curb radii. Figure 8-10 illustrates the turning paths of several design vehicles where radii are 15 feet or 25 feet and



- ① Full-depth pavement will begin where encroachment onto shoulder begins and will continue until encroachment ends.
- ② Dimensions shown are for illustrative purposes. As discussed in Section 8-2, actual dimensions will be determined case-by-case based on field conditions.

EFFECTS OF PARKING LANES/SHOULDERS ON VEHICULAR TURNING PATHS

Figure 8-10

where 8-foot to 10-foot parking lanes are provided. The presence of a shoulder 8-foot to 10-foot in width will have the same impact as a parking lane.

The figure also illustrates the necessary distance to restrict parking before the P.C. (15 feet) and after the P.T. (20 to 40 feet) on the cross street. The designer will, of course, need to check the proposed design with the applicable turning template and encroachment criteria. The designer should not consider the beneficial effects of a parking lane if the lane will be used for through traffic part of the day or if parking will likely be prohibited in the future.

Figure 8-10 indicates approximately where the parking lane or shoulder will have a full-depth pavement structure. This treatment is critical to avoid pavement deterioration from trucks turning at the intersection.

8-2.05 Pedestrians

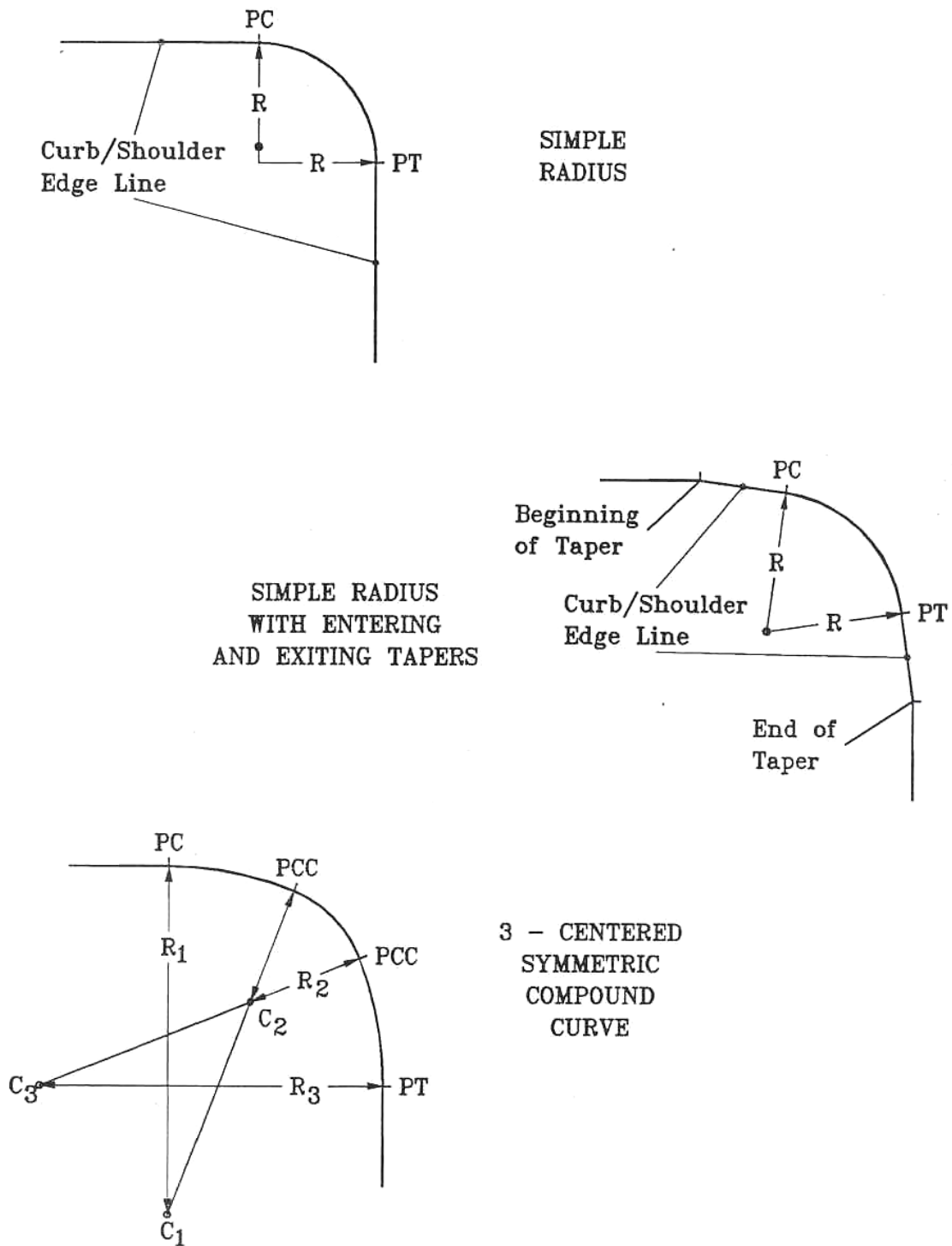
The greater the turning radius or the number of lanes, the farther pedestrians must walk in the roadway. This is especially important to handicapped individuals. Therefore, the designer should consider this when determining the edge of pavement or curb line design. This may lead to, for example, the decision to use a simple curve with taper offsets or a 3-centered compound curve (see Section 8-2.06) or a turning roadway (see Section 8-3) to provide a pedestrian refuge.

8-2.06 Types of Turning Designs

Once the designer has determined the basic turning parameters (e.g., design vehicle, encroachment, inside clearance), it is necessary to select a type of turning design for the curb return which will meet these criteria and will fit the intersection constraints. The design may be one of the following basic types:

1. simple radius,
2. simple radius with entering and exiting tapers, or
3. 3-centered symmetrical compound curve.

Figure 8-11 illustrates all three basic turning designs. Each design type has its advantages and disadvantages. The simple radius is the easiest to design and construct and, therefore, it is the most common. The 3-centered symmetrical compound curve arrangement provides the "best" fit to the transitional turning paths of vehicles. However, the designer should also consider the



TYPES OF INTERSECTION TURNING DESIGNS

Figure 8-11

benefits of the simple radius with an entering and exiting taper. Some advantages of the simple radius/taper or 3-centered curve designs (as compared to the simple radius design) include:

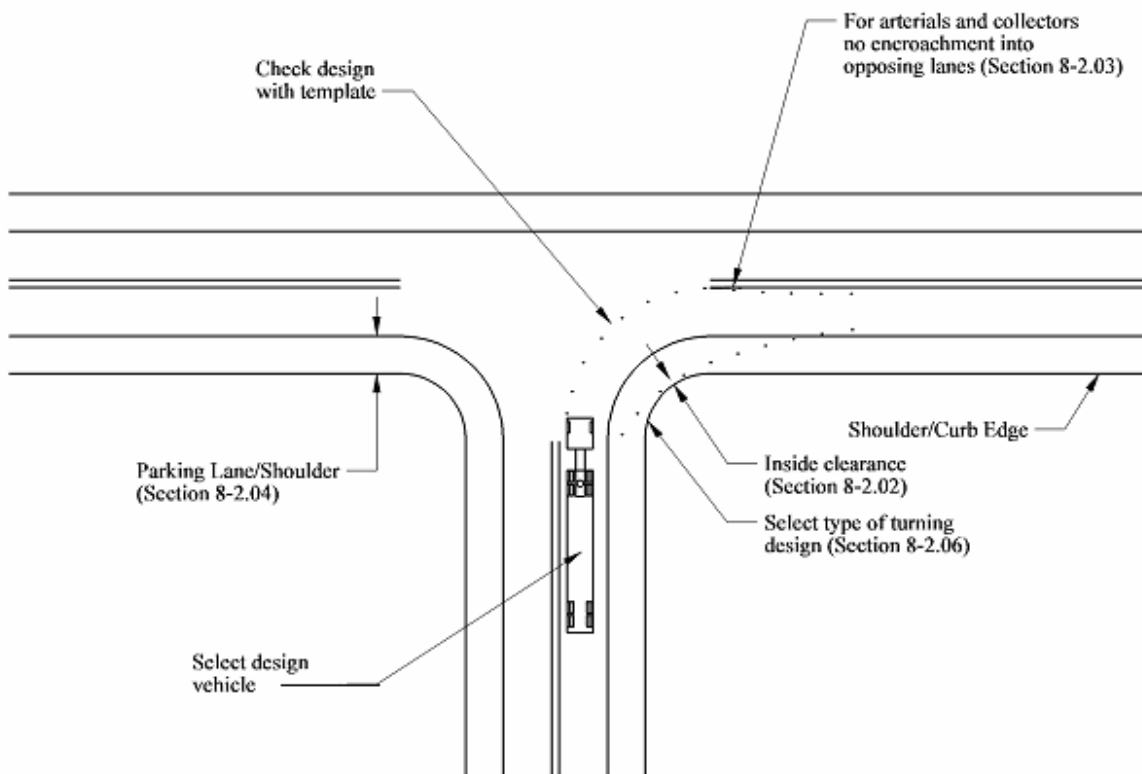
1. To accommodate a specific vehicle with no encroachment, a simple radius requires greater intersection pavement area than a radius with tapers or 3-centered curve. Another benefit is the reduced right-of-way impact in the intersection corners. For large vehicles, a simple radius is often an unreasonable design, unless a channelized island is used.
2. A simple radius results in greater distances for pedestrians to cross than a radius with tapers or a 3-centered curve.
3. For angles of turn greater than 90°, a radius with tapers or a 3-centered curve is a better design than a simple radius, primarily because less intersection area is required.
4. The simple radius with tapers provides approximately the same transitional benefits as the compound curvature arrangements, but it is easier to design, survey and construct.

8-2.07 Summary

Figure 8-12 illustrates the many factors which should be evaluated in determining the proper design for right turns at intersections. In summary, the following procedure applies:

1. Select the design vehicle (typically the WB-67).
2. Determine the acceptable inside clearance (Section 8-2.02).
3. Determine the acceptable encroachment (Section 8-2.03).
4. Consider the benefits of any parking lanes or shoulders (Section 8-2.04).
5. Consider impacts on pedestrians (Section 8-2.05).
6. Select the type of turning treatment (Section 8-2.06):
 - a. simple radius,
 - b. simple radius with entering and exiting tapers, or
 - c. 3-centered compound curve.

7. Check all proposed designs with the applicable vehicular turning template.
8. Revise design as necessary to accommodate the right-turning vehicle or determine that it is not practical to meet this design because of adverse impacts.



TURNING RADII DESIGN

Figure 8-12

8-3 TURNING ROADWAYS

Turning roadways are channelized areas (separated by an island) which allow a moderate-speed, free-flowing right turn away from the intersection area. The designer should consider using turning roadways when:

1. it is desirable to allow right turns at speeds of 15 mph or more;
2. the angle of turn is greater than 90°;
3. the volume of right turns is high, the turning movement is from a high-volume road or it is desirable to remove right turns away from a signal;
4. it is desirable to reduce the intersection paved area. As a guide, if an island with a turning roadway will be at least 75 square feet (urban) or 100 square feet (rural), then a turning roadway should be considered; and/or
5. pedestrian volumes are high and a pedestrian refuge is a desirable feature.

Figure 8-13 illustrates a possible design for a turning roadway at an urban intersection. This figure presents a turning roadway with a 3-centered compound curve, although a simple curve is often acceptable. Table 8-1 presents the minimum radii, superelevation and width for various design speeds. The following sections discuss the design details of a turning roadway.

8-3.01 Design Speed

The designer must select a controlling design speed for the turning roadway. Typically, the design speed will be in the range of 15-20 mph. It is desirable, however, that the design speed on the turning roadway be within 10 mph of the design speed on the approaching highway. This may be impractical because of restrictive site conditions. A turning roadway at a low design speed (e.g., 15 mph) will still provide a significant benefit to the turning vehicle regardless of the speed on the approaching highway; therefore, it is not critical to ensure that the design speed on the turning roadway is within 10 mph of the approaching highway speeds.

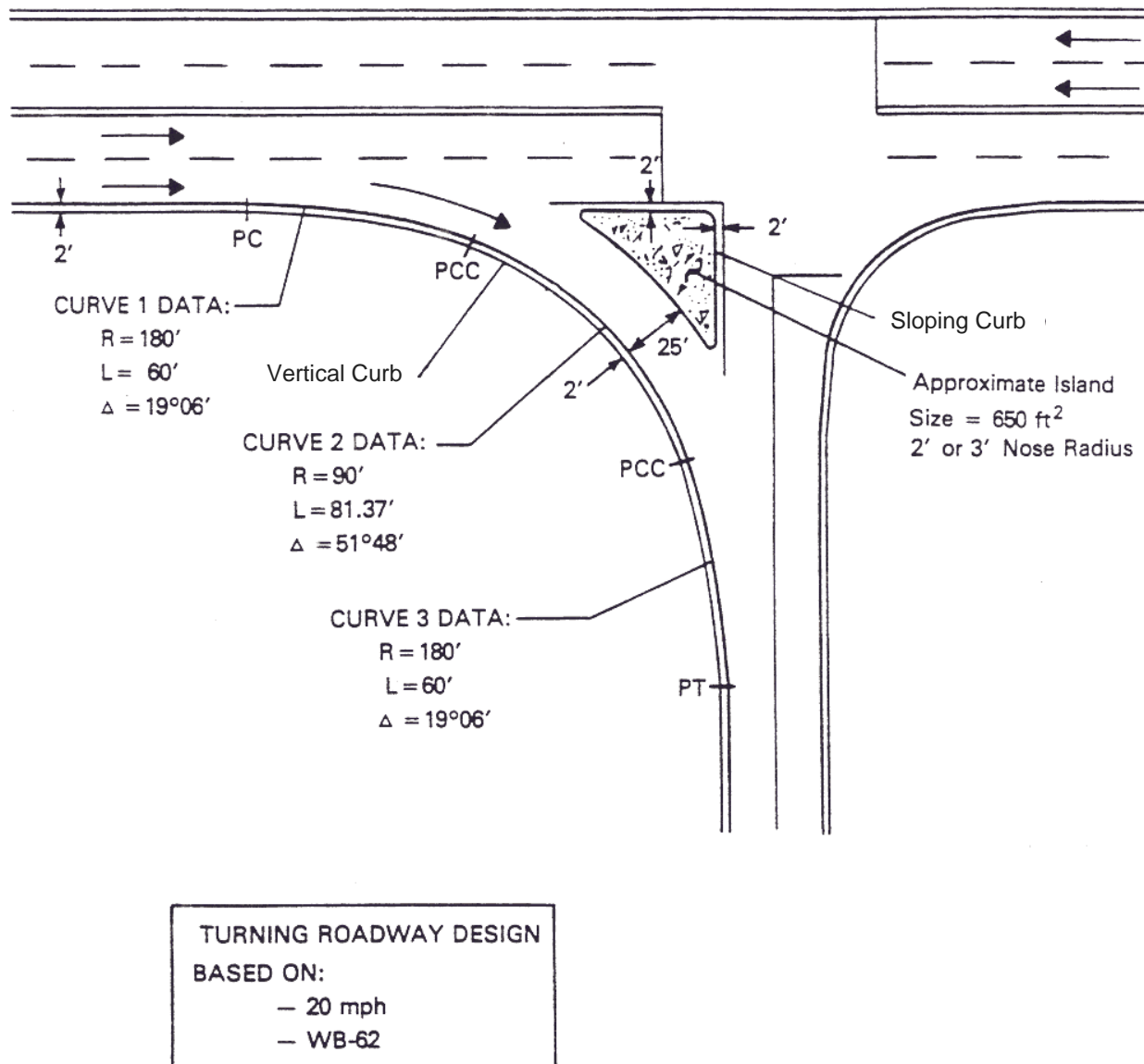


ILLUSTRATION OF A TURNING ROADWAY DESIGN

Figure 8-13

Turning Roadway Design Speed (mph)	Maximum Side Friction (f)	Super-elevation (e)	Minimum Radius (ft)	Width (ft)
15	0.35	2.0% 4.0% 6.0%	45 45 40	26
20	0.28	2.0% 4.0% 6.0%	95 85 80	25
25	0.23	2.0% 4.0% 6.0%	170 155 145	21
30	0.19	2.0% 4.0% 6.0%	275 250 230	19
35	0.17	2.0% 4.0% 6.0%	410 375 340	18
40	0.14	2.0% 4.0% 6.0%	595 535 485	17

- Notes:**
1. The widths in the table are based on a WB-62 but this figure can be used for the WB-67 design vehicle.
 2. If a curb is present on the mainline approaching the turning roadway, the curb offset should be maintained throughout the turning roadway; i.e., the curb offset width will be in addition to the widths in the table. No additional width is necessary on the left side with or without a curb.
 3. The widths in the table apply to angles of intersection of 90 degrees or less between the two main highways. The following criteria apply for intersecting angles greater than 90 degrees (for 15 mph only):

<u>Angle of Turn</u>	<u>Width of Turning Roadway</u>
105°	33 ft
120°	37 ft
135°	38 ft
150°	41 ft

DESIGNS FOR TURNING ROADWAYS

Table 8-1

8-3.02 Horizontal Curvature

At most turning roadways, a simple curve throughout will be acceptable. However, the designer should consider the use of a 3-centered compound curve, especially where the difference between the design speeds of the approaching highway and the turning roadway is more than 15 mph. This provides the driver with some transition into and out of the turning roadway.

If a 3-centered curve is used, the radius of the flatter curve should be no more than twice the radius of the sharper curve. In addition, the lengths of the entering and exiting curves should meet the criteria in Table 8-2.

Radius (ft)	100 or less	150	200	250	300	400	500+
Minimum Length (ft)	40	50	60	80	100	120	140
Desirable Length (ft)	60	70	90	120	140	180	200

**LENGTHS OF ENTERING/EXITING CURVES
(3-Centered Curve)**

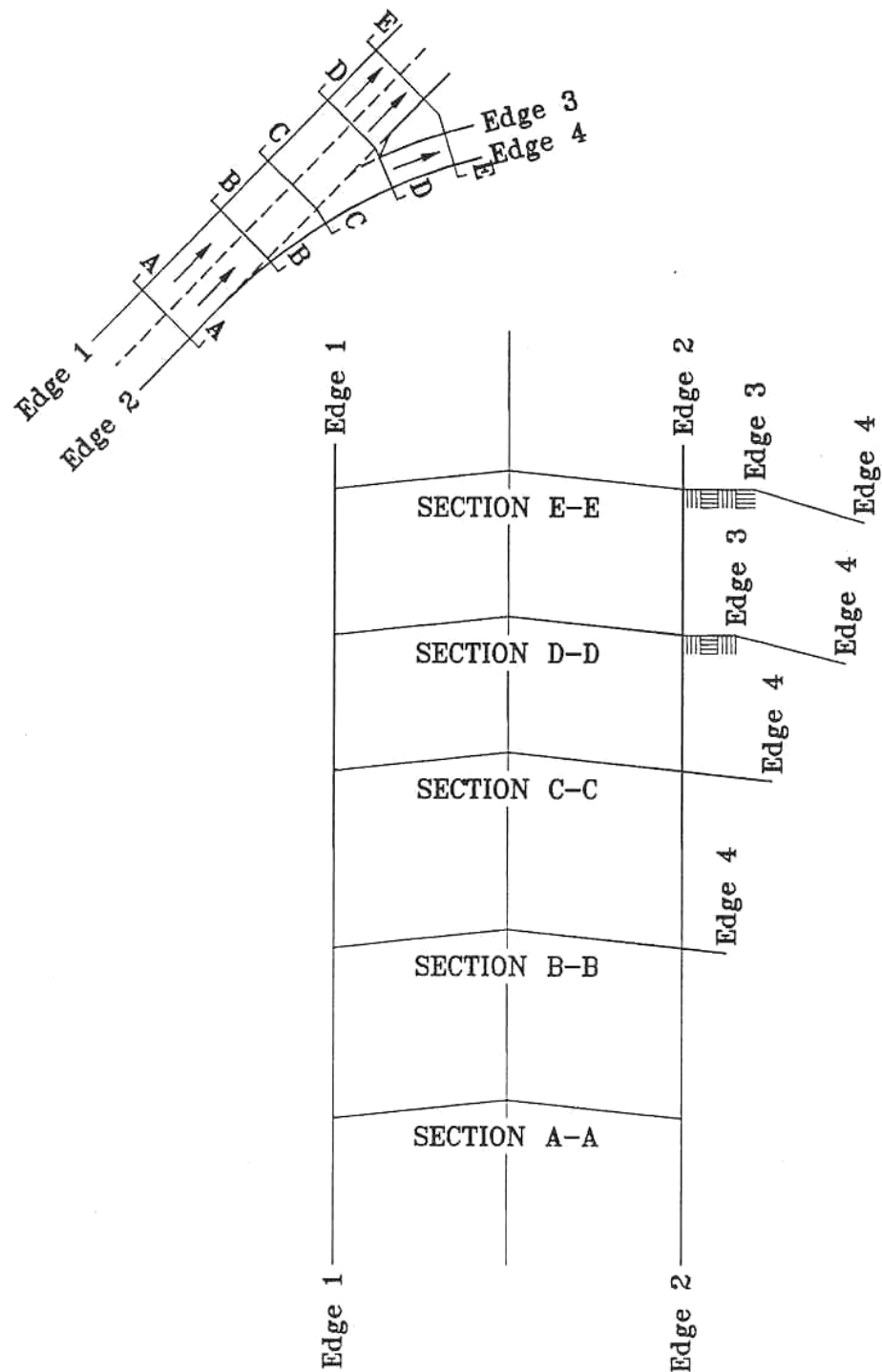
Table 8-2

8-3.03 Superelevation

Superelevation development on turning roadways need not meet the rigid criteria used on open highways. The practicality of quickly introducing and removing a curve at an intersection requires flexibility. In many cases, the superelevation rate throughout the roadway will be 2.0%, the typical cross slope.

Figure 8-14 illustrates a schematic of superelevation development at a turning roadway. The actual development will depend upon the practical field conditions with some consideration to limiting factors. The following criteria will apply:

1. **Rate.** Superelevation will range between 2.0% and 6.0%.
2. **Axis of Rotation.** The point will normally be rotated about Edge 3 in Figure 8-14.



DEVELOPMENT OF SUPERELEVATION AT TURNING ROADWAY TERMINALS

Figure 8-14

3. **Transition Length.** This will depend upon actual field conditions. Assuming the cross slope on the approaching mainline is 2.0%, the designer should attempt to meet the following criteria (as practical):
 - a. If the superelevation rate on the turning roadway will be approximately 4.0%, the transition length should be 50 feet.
 - b. If the superelevation rate on the turning roadway will be approximately 6.0%, the transition length should be 100 feet.
4. **Distribution.** Full superelevation should be reached, if actual field conditions allow, at the first 50-foot station occurring a minimum distance of 25 feet beyond section D-D in Figure 8-14. The beginning of the transition will occur at least 50 feet or 100 feet (whichever applies) in advance of the station where full superelevation is reached.
5. **Cross Slope Rollover.** Superelevation development may also depend upon the allowable cross slope rollover between the mainline and the turning roadway. (See Table 8-3). This will likely only be a factor when a superelevated mainline is curving to the left.

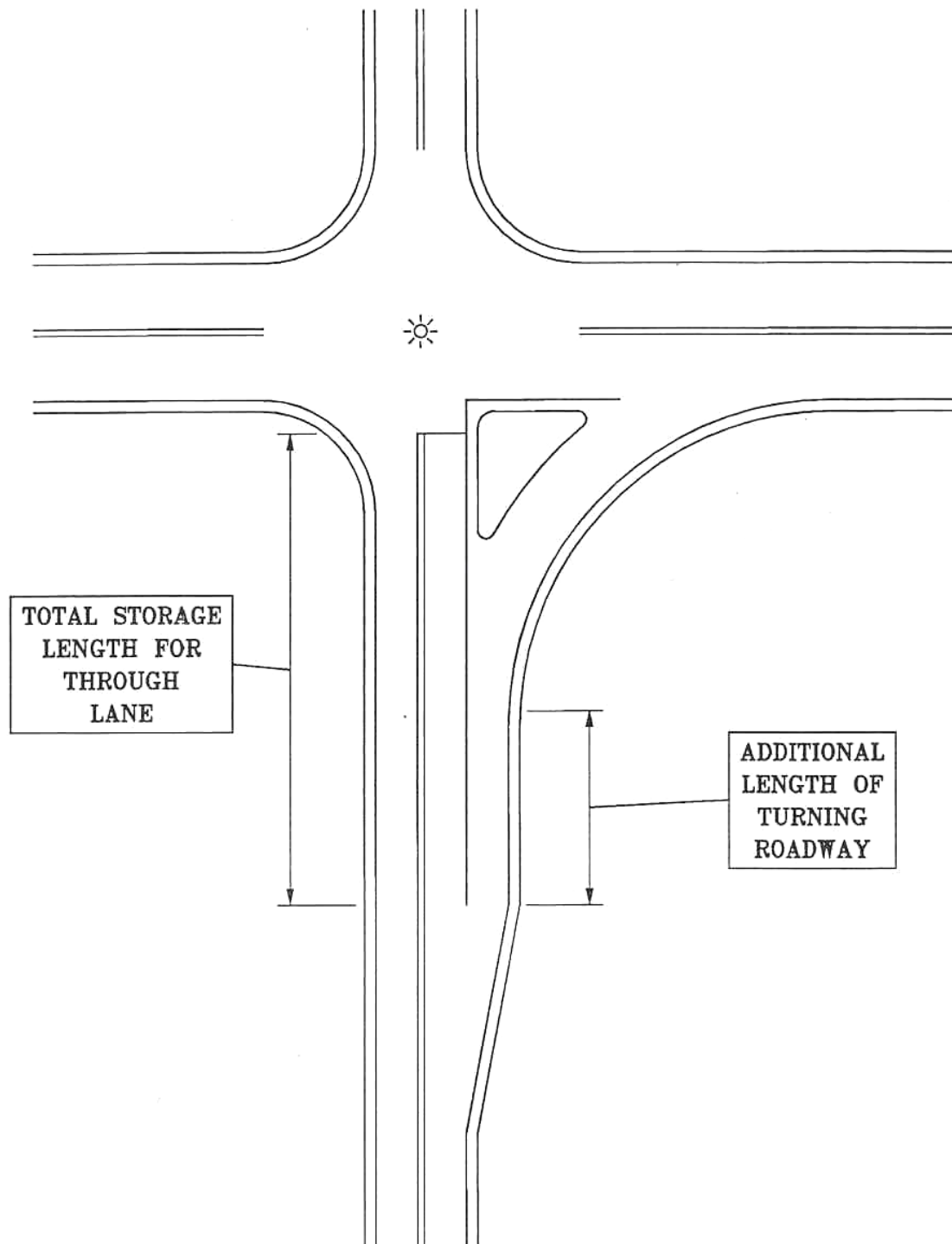
Design Speed of Curve at Section D-D (mph)	Maximum Algebraic Difference in Cross Slope at Crossover Line (percent)
≤ 20	5-8
25-30	5-6
> 30	4-5

**PAVEMENT CROSS SLOPE AT
TURNING ROADWAY TERMINALS**

Table 8-3

8-3.04 Additional Length

At signalized intersections, the storage length on the mainline may block the entrance into the turning roadway. The designer should extend the turning roadway beyond the mainline storage length to allow access by right-turning vehicles. See the schematic in Figure 8-15.



ADDITIONAL LENGTH OF TURNING ROADWAY
(Signalized Intersections)

Figure 8-15

8-4 AUXILIARY TURNING LANES

8-4.01 Warrants for Right-Turn Lanes

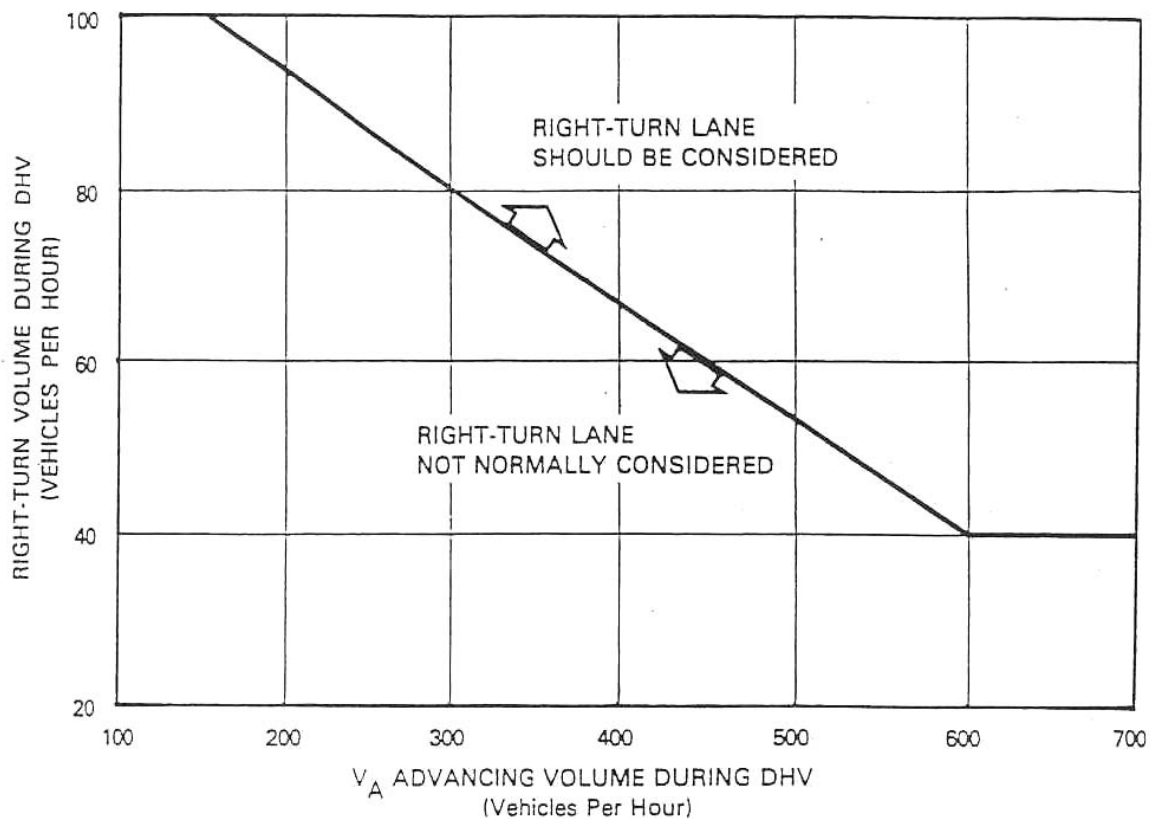
Exclusive right-turn lanes should be considered:

1. at any unsignalized intersection on a two-lane urban or rural highway which satisfies the criteria in Figure 8-16;
2. at any intersection where a capacity analysis determines a right-turn lane is necessary to meet the level-of-service criteria; or
3. at any intersection where the accident experience, existing traffic operations or engineering judgment indicates a significant hazard related to right-turning vehicles.

8-4.02 Warrants for Left-Turn Lanes

Exclusive left-turn lanes should be considered:

1. at all median openings on divided urban and rural highways without full control of access with a median wide enough to accommodate a left-turn lane;
2. at any unsignalized intersection on a two-lane highway which satisfies the criteria in Figures 8-17 to 8-19;
3. at any intersection where a capacity analysis determines a left-turn lane is necessary to meet the level-of-service criteria; or
4. at any intersection where the accident experience, existing traffic operations, adverse geometrics (e.g., restricted sight distance) or engineering judgment indicates a significant hazard related to left-turning vehicles.



Note: For highways with a design speed below 50 mph and $DHV < 300$ and Right Turns > 40 , an adjustment should be used. To read the vertical axis of the chart, subtract 20 from the actual number of right turns.

Example

Given: Design Speed = 40 mph
 $V_A = 250$ vph
 Right Turns = 100 vph

Problem: Determine if a right-turn lane should be considered.

Solution: To read the vertical axis, use $100 - 20 = 80$ vph. The figure indicates that a right-turn lane should not normally be considered, unless other factors (e.g., high accident rate) indicate a lane is needed.

GUIDELINES FOR RIGHT-TURN LANES AT UNSIGNALIZED INTERSECTIONS ON 2-LANE HIGHWAYS

Figure 8-16

* * * * *

Example 1

Given: Design Speed = 60 mph
DHV (2 way) = 600 vph
Directional Distribution = 60/40
Left Turns (at an unsignalized intersection) = 10% of heavy flow

Problem: Determine if a left-turn lane should be considered.

Solution:

STEP 1: A 60/40 directional distribution yields 360 vph in one direction and 240 vph in the other. To use Figure 8-17 (for 60 mph):

$$V_A = 360 \text{ vph}$$

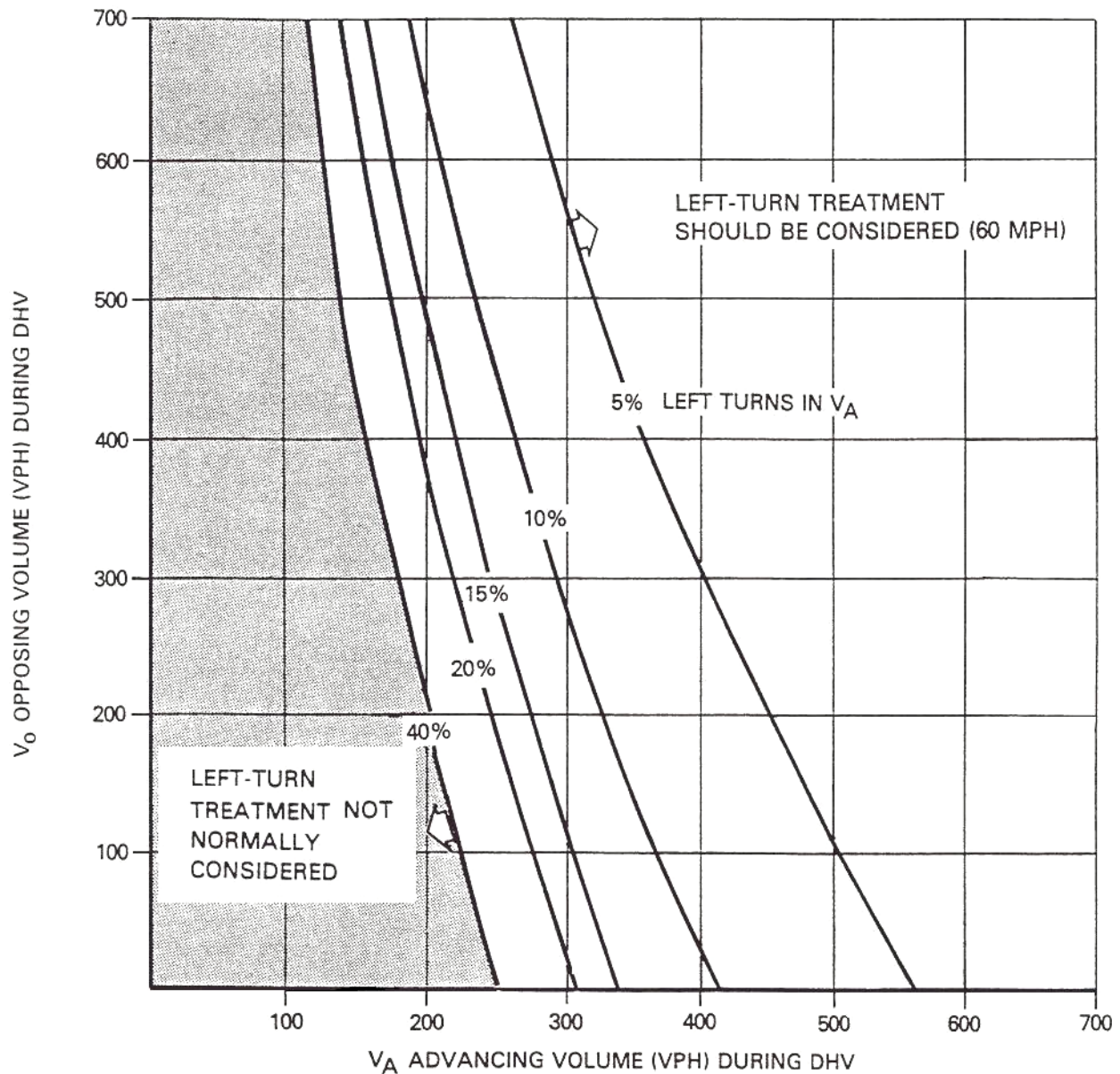
$$V_O = 240 \text{ vph}$$

STEP 2: Use the 10 percent curve on Figure 8-17.

STEP 3: Read V_A (360 vph) and V_O (240 vph) into the chart and locate the intersection point as shown on Figure 8-17.

STEP 4: The point from Step 3 is located to the right of the 10 percent curve. Therefore, a left-turn lane should be considered.

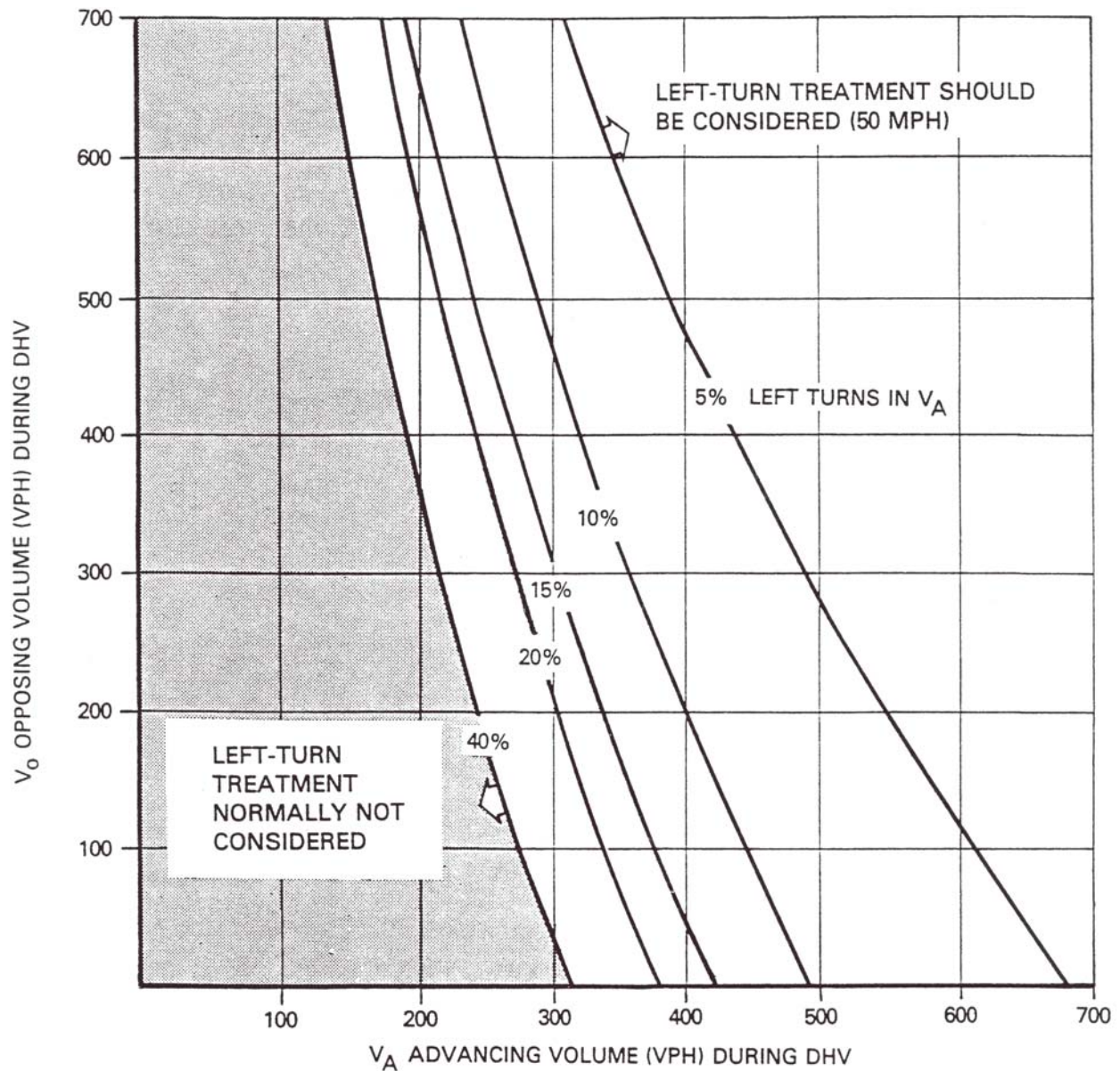
* * * * *

**Instructions:**

1. The family of curves represent the percent of left turns in the advancing volume (V_A). The designer should locate the curve for the actual percentage of left turns. When this is not an even increment of 5, the designer should estimate where the curve lies.
2. Read V_A and V_O into the chart and locate the intersection of the two volumes.
3. Note the location of the point in #2 relative to the line in #1. If the point is to the right of the line, then a left-turn lane is warranted. If the point is to the left of the line, then a left-turn lane is not warranted based on traffic volumes.

**VOLUME WARRANTS FOR LEFT-TURN LANES
AT UNSIGNALIZED INTERSECTIONS ON 2-LANE HIGHWAYS
(60 mph)**

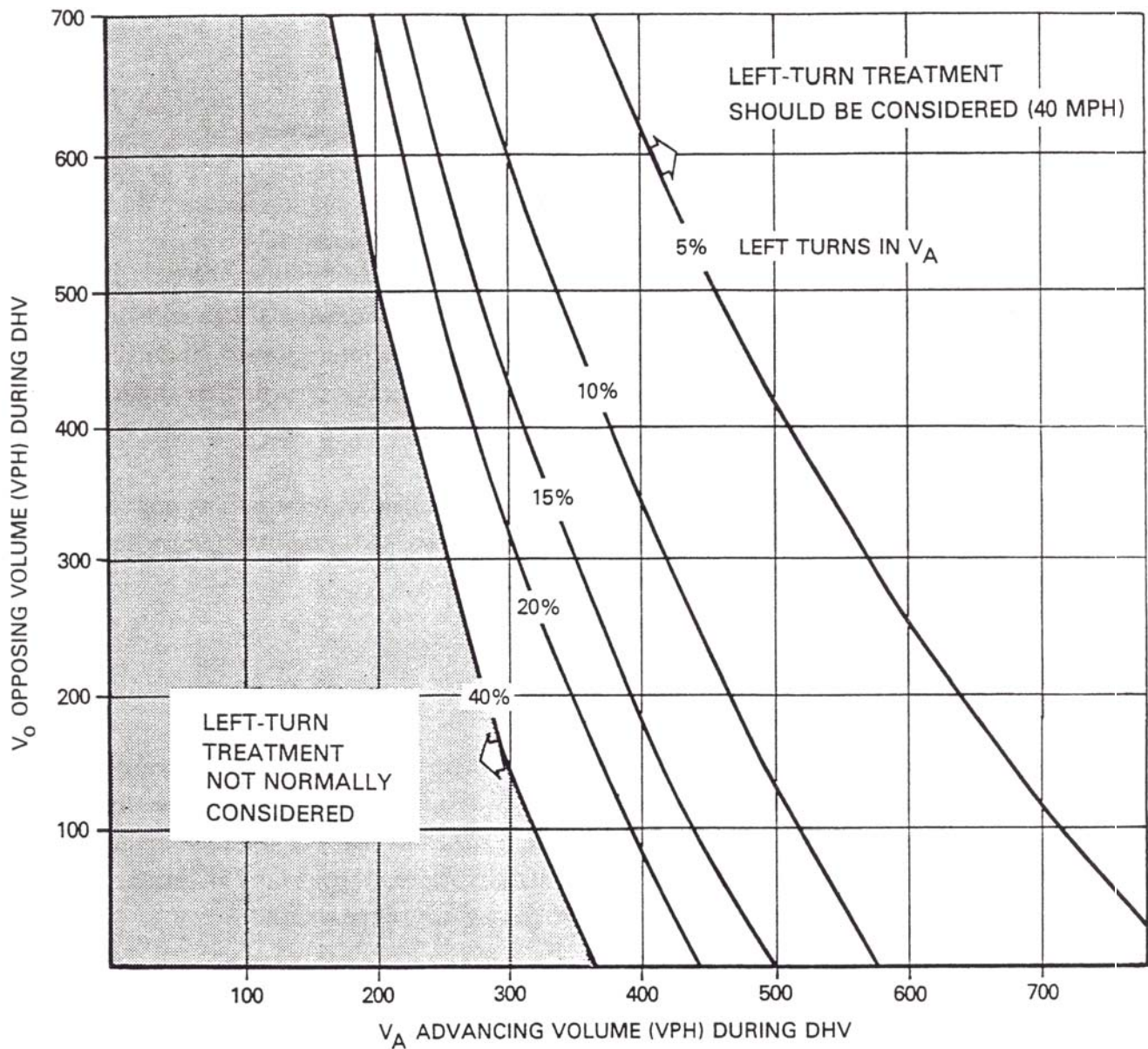
Figure 8-17

**Instructions:**

1. The family of curves represent the percent of left turns in the advancing volume (V_A). The designer should locate the curve for the actual percentage of left turns. When this is not an even increment of 5, the designer should estimate where the curve lies.
2. Read V_A and V_O into the chart and locate the intersection of the two volumes.
3. Note the location of the point in #2 relative to the line in #1. If the point is to the right of the line, then a left-turn lane is warranted. If the point is to the left of the line, then a left-turn lane is not warranted based on traffic volumes.

**VOLUME WARRANTS FOR LEFT-TURN LANES
AT UNSIGNALIZED INTERSECTIONS ON 2-LANE HIGHWAYS
(50 mph)**

Figure 8-18

**Instructions:**

1. The family of curves represent the percent of left turns in the advancing volume (V_A). The designer should locate the curve for the actual percentage of left turns. When this is not an even increment of 5, the designer should estimate where the curve lies.
4. Read V_A and V_O into the chart and locate the intersection of the two volumes.
5. Note the location of the point in #2 relative to the line in #1. If the point is to the right of the line, then a left-turn lane is warranted. If the point is to the left of the line, then a left-turn lane is not warranted based on traffic volumes.

**VOLUME WARRANTS FOR LEFT-TURN LANES
AT UNSIGNALIZED INTERSECTIONS ON 2-LANE HIGHWAYS
(40 mph)**

Figure 8-19

8-4.03 Design of Auxiliary Turning Lanes

The following criteria will apply to the design of auxiliary turning lanes:

1. **Length**. Figure 8-20 illustrates a schematic of auxiliary lanes at an intersection. Table 8-4 presents the criteria for determining the length of the turning lane.
2. **Width**. The width of the turn lane should be according to the functional class, urban/rural location and project scope of work. Chapters Seven and Eleven present the applicable widths for auxiliary lanes, and they present the criteria for shoulder/curb offset width from the auxiliary lane.
3. **Parking Lanes**. A right-turn lane in an urban area will often require parking restrictions beyond the typical restricted distance from the intersection. Also, it may require relocating nearside bus stops to the far side of the intersection.

8-4.04 Bypass Lanes

Figure 8-21 illustrates the typical design for a bypass lane. This is a relatively inexpensive design to provide for through and left-turn movements at intersections. The bypass lane is appropriate for T-intersections (signalized or unsignalized) where left-turning volumes are light to moderate. It may also be appropriate at 4-way intersections; however, if right-turn volumes are high enough to warrant a right-turn lane (see Figure 8-16), do not use a bypass lane.

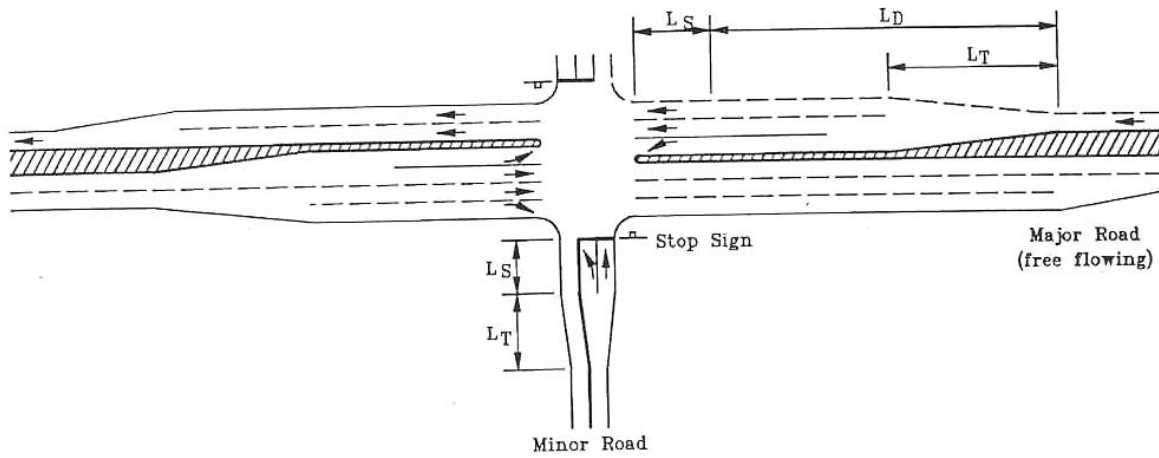
The decision to use either a channelized left-turn lane or the bypass lane will be based on comparative costs, accident history, right-of-way availability, through and turning traffic volumes, design speed and available sight distance.

8-4.05 Dual Turn Lanes

Warrants

Dual right- and/or left-turn lanes should be considered when:

1. there is not sufficient space to provide the necessary length of a single turn lane because of restrictive site conditions (e.g., closely spaced intersections);
2. the necessary length of a single turn lane becomes prohibitive; or



Note: The schematic of the major road (free flowing) also applies to all legs of a signalized intersection.

Key:

- L_T = Taper Length
- L_D = Deceleration Length
- L_S = Storage Length

TYPICAL AUXILIARY LANES AT AN INTERSECTION

Figure 8-20

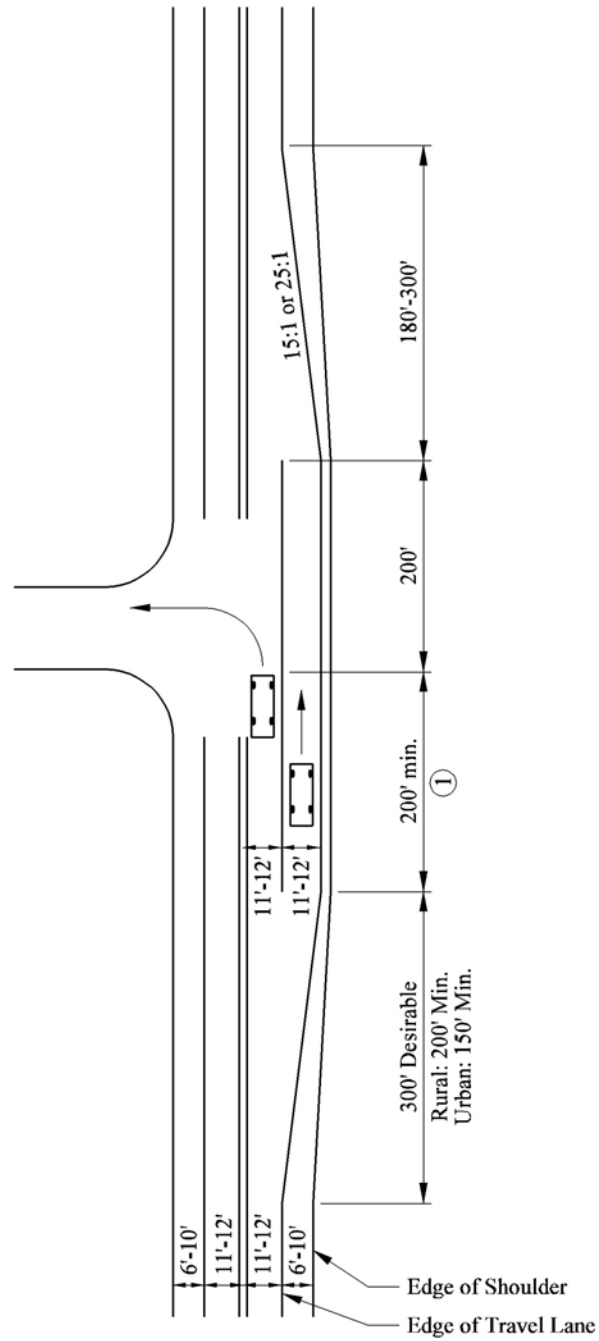
Design Element	Design Speed (mph)	Traffic Control	Criteria (See Notes 1, 6, 7)	
Taper Rate when Straight Through Movement Changes Lanes	<45	All	$W \times S^2/60$	
	≥ 45		$W \times S$	
Taper Rate when Straight Through Movement Stays in Lane	30 40 50 +	All	8:1 10:1 15:1	
Deceleration Length (L_D) (See Notes 2, 3)	30 40 50 60	All (See Note 2)	120 ft 165 ft 265 ft 370 ft	
Storage Length (L_S) (See Note 4)	All	Unsignalized (See Note 4)	Turning DHV (vph)	L_S
			<61 61-120 121-180 > 180	Minimum Length 100 150 ≥ 200
		Signalized (See Notes 4, 5, 6)	Based on 1.5 - 2.0 times the average number of cars that will store in the turning lane per cycle during the design hour.	

Notes:

1. Minimum Length. The minimum length of an auxiliary turning lane will be the taper length (L_T) plus the storage length (L_S).
2. Use of Deceleration Length. The designer should consider providing the deceleration length (L_D), if practical, at the following:
 - a) legs of a signalized intersection (except the truncated leg of signalized T-intersection); and
 - b) the free-flowing legs of a stop-controlled intersection for the left-turn lane.

Deceleration length need not be considered at stop-control legs, nor at the truncated leg of a signalized T-intersection, nor at a right-turn lane for the free flowing leg at a stop-controlled intersection.
3. Measurement of Deceleration Length. As illustrated in Figure 8-20, the deceleration length (L_D) also includes the taper length (L_T). The L_D values in the table assume that the turning vehicle is traveling at a speed of approximately 5 mph below the average running speed before entering the taper.
4. Minimum Storage Length. For all intersections where traffic volumes are too low to govern, the minimum length will be 50 ft ($T \leq 10\%$) or 80 ft ($T > 10\%$), where T is the percent of trucks turning.
5. Coordination. The Traffic Engineering Division should provide the storage length (L_S) required at signalized intersections.
6. Storage Length of Through Traffic. In addition to the table criteria, the length of turning lanes at signalized intersections should exceed the calculated storage length in the through lane adjacent to the turning lane for the design hour.
7. (W = width of the travel lane in feet, S = design or posted speed of roadway in mph.)

RECOMMENDED LENGTHS OF AUXILIARY TURNING LANES
Table 8-4

**Note:**

① The desirable length is the storage based on 2-minute arrival period plus 100'.

TYPICAL BYPASS LANE ON A TWO-LANE HIGHWAY

Figure 8-21

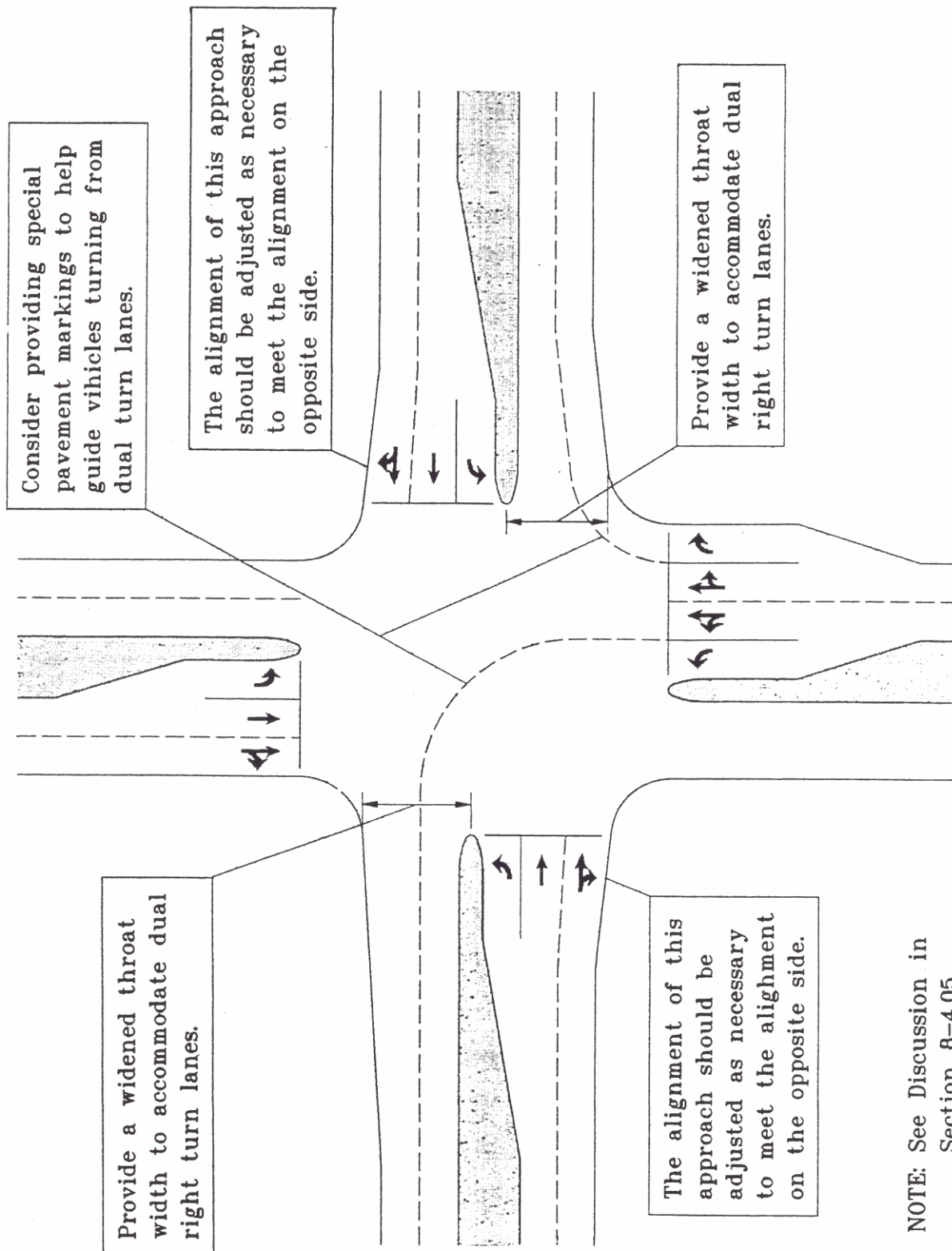
3. the necessary time for a protected left-turn phase for a single lane becomes unattainable to meet the level-of-service criteria (average delay per vehicle).

Dual right-turn lanes do not work as well as dual left-turn lanes because of the more restrictive turning movements for two abreast right turns. If practical, the designer should find an alternative means to accommodate a high number of right-turning vehicles. For example, a turning roadway may accomplish this purpose.

Design

For dual turning lanes to work properly, several design elements must be carefully evaluated. Figure 8-22 presents both dual right- and left-turn lanes to illustrate the more important design elements. The designer should consider the following:

1. **Throat Width.** Because of the off-tracking characteristics of turning vehicles, the normal width of two travel lanes may be inadequate to properly receive two vehicles turning abreast. Therefore, the receiving throat width may need to be widened. The throat width will be determined by the application of the turning templates for the design vehicles (see No. 5). The designer can expect that the width for dual turn lanes will be approximately 30-36 feet. When determining the available throat width, the designer can assume that a paved shoulder, if present at the receiving throat, will be used to accommodate two-abreast turns.
2. **Widening Approaching Through Lanes.** If a widened throat width is provided to receive dual turn lanes, the designer should also consider how this will affect the traffic approaching from the other side. The approach to the intersection should desirably be within 6 feet of the throat width. The designer should also ensure that the through lanes line up relatively well to allow a smooth flow of traffic through the intersection. The decision on a widened approach and pavement markings should be coordinated with the Traffic Engineering Division.
3. **Special Pavement Markings.** As illustrated in Figure 8-22, these can effectively guide two lines of vehicles turning abreast. The Traffic Engineering Division will determine the selection and placement of any special pavement markings.
4. **Opposing Left-Turn Traffic.** If simultaneous, opposing dual left turns will be allowed, the designer should ensure that there is sufficient space for all turning movements. This is a



DESIGN OF DUAL TURN LANES

Figure 8-22

factor at all signalized intersections, but dual left-turn lanes with their two-abreast vehicles can cause special problems. If space is unavailable, it may be necessary to alter the signal phasing to allow the two directions of traffic to move through the intersection on separate phases. The intersection layout will be coordinated with the Traffic Engineering Division.

5. **Turning Templates**. All intersection design elements for dual turn lanes must be checked by using the applicable turning templates. The designer should assume that the WB-62 design vehicle will turn from the inside lane of the dual turn lane, which is the more difficult turning maneuver. The other vehicle can be assumed to be a passenger vehicle turning side by side with the WB-62.

8-5 CONTINUOUS TWO-WAY LEFT-TURN LANES

Continuous two-way left-turn lanes (CTWLTL) are used as a cost-effective method to accommodate a continuous left-turn demand and to reduce delay and accidents. These lanes will often improve operations on roadways which were originally intended to serve the through movement but now must accommodate the demand for accessibility created by changes in adjacent land use.

All proposed locations and proposed design details for a CTWLTL should be coordinated with the Traffic Engineering Division.

8-5.01 Warrants

Functional Class

An undivided 2-lane or 4-lane urban arterial is the most common candidate for the implementation of a CTWLTL.

Traffic Volumes

Traffic volumes are a significant factor in the consideration of a CTWLTL. As general guidance, the following should be used:

1. On existing 2-lane roadways, a CTWLTL will often be advantageous for traffic volumes between 5,000 and 12,500 AADT.
2. On existing 4-lane highways, a CTWLTL will often be advantageous for traffic volumes between 10,000 and 25,000 AADT. For traffic volumes greater than 25,000 AADT, a raised median may be the more advantageous design selection.

Pedestrian crossing volumes are also a consideration because of the large paved area which must be traversed when a CTWLTL is present.

Speed

The design speed on a highway facility is a major factor in CTWLTL applications. Experience indicates that design speeds from 25 mph to 45 mph will properly accommodate a CTWLTL.

Design speeds higher than 45 mph may cause concern because of a possible increased accident potential.

Accident History

On high-volume urban arterials, traffic conflicts often result because of a significant number of mid-block left turns combined with significant opposing traffic volumes. This may lead to disproportionate numbers of mid-block, rear-end and sideswipe accidents. A CTWLTL is likely to reduce these types of accidents. The designer should review and evaluate the available accident data to determine if unusually high numbers of these accidents are occurring.

Adjacent Land Use

The mid-block, rear-end and sideswipe accidents usually result from high-density, strip commercial development along the highway. This type of land use will normally generate left turns throughout the day.

8-5.02 Design Criteria

Lane Width

Recommended lane widths for a CTWLTL and various design speeds are presented in Chapters Seven and Eleven. Existing highways that warrant the installation of a CTWLTL are often located in areas of restricted right-of-way. Conversion of the existing cross section may be difficult. To obtain the CTWLTL width, the design may have to consider several alternatives including:

1. removing an existing raised median,
2. reducing the width of existing through lanes,
3. reducing the number of existing through lanes,
4. eliminating existing parking lanes,
5. eliminating or reducing the width of existing shoulders, and/or
6. acquiring additional right-of-way to expand the pavement width by the amount needed for the CTWLTL.

Intersection Treatment

At all intersections with public roads, the CTWLTL must either 1) be terminated in advance to allow the development of an exclusive left-turn lane or 2) be extended up to the intersection area. In most cases where the CTWLTL is extended up to the intersection, the pavement marking will switch from two opposing left-turn arrows to one left-turn arrow only. When determining the intersection treatment, the following should be considered:

1. **Functional Classification.** All intersecting arterials and many collectors will warrant an exclusive left-turn lane. The majority of intersecting local streets and some collector streets may not warrant an exclusive left-turn lane.
2. **Turning Volumes.** The left-turn demand into the intersecting road is a factor in determining the proper intersection treatment. The following may be used as general guidance: If the minimum storage length will govern (Section 8-4.03), then it will probably be warranted to extend the CTWLTL up to the intersection (i.e., provide no exclusive left-turn lane).
3. **Minimum Length of CTWLTL.** The CTWLTL should have sufficient length to operate properly, and the type of intersection treatment will determine the length of the CTWLTL. The minimum length will be influenced by through traffic volumes, turning volumes and operating speeds on the highway. The following guidance may be used:
 - a. On facilities where $V \leq 30$ mph and/or lower traffic volumes exist, the recommended uninterrupted length of a CTWLTL should be 300-500 feet.
 - b. On facilities where $V > 30$ mph and/or higher traffic volumes exist, the recommended uninterrupted length of a CTWLTL should be 500-800 feet.

The final decision on the length of the CTWLTL will be based on site conditions.

4. **Operational/Safety Factors.** Extending the CTWLTL up to an intersection could result in operational or safety problems. Some drivers may, for example, pass through the intersection in the CTWLTL and turn left beyond the intersection into a driveway which is very close to the intersection (e.g., within 100 feet). If operational or safety problems are known or anticipated at an intersection, this is a factor in determining the proper intersection treatment.

Transition

Transitions may be required at the beginning and ending of a CTWLTL. The length of transition should be computed by using the following equations:

1. $L = WS$ ($S > 45$ mph)
2. $L = WS^2/60$ ($S \leq 45$ mph)

where:

- L = length of transition, ft
 W = width of transition, ft
 S = design speed, mph

In most cases, W will be equal to one-half the width of the CTWLTL.

Traffic Control Devices

A CTWLTL requires proper signing and pavement markings to reduce indecision and misuse. Criteria for signing and markings are presented in the MUTCD. The Traffic Engineering Division will determine the proper application of traffic control devices

8-6 MEDIAN OPENINGS

8-6.01 Warrants

Non-Freeways

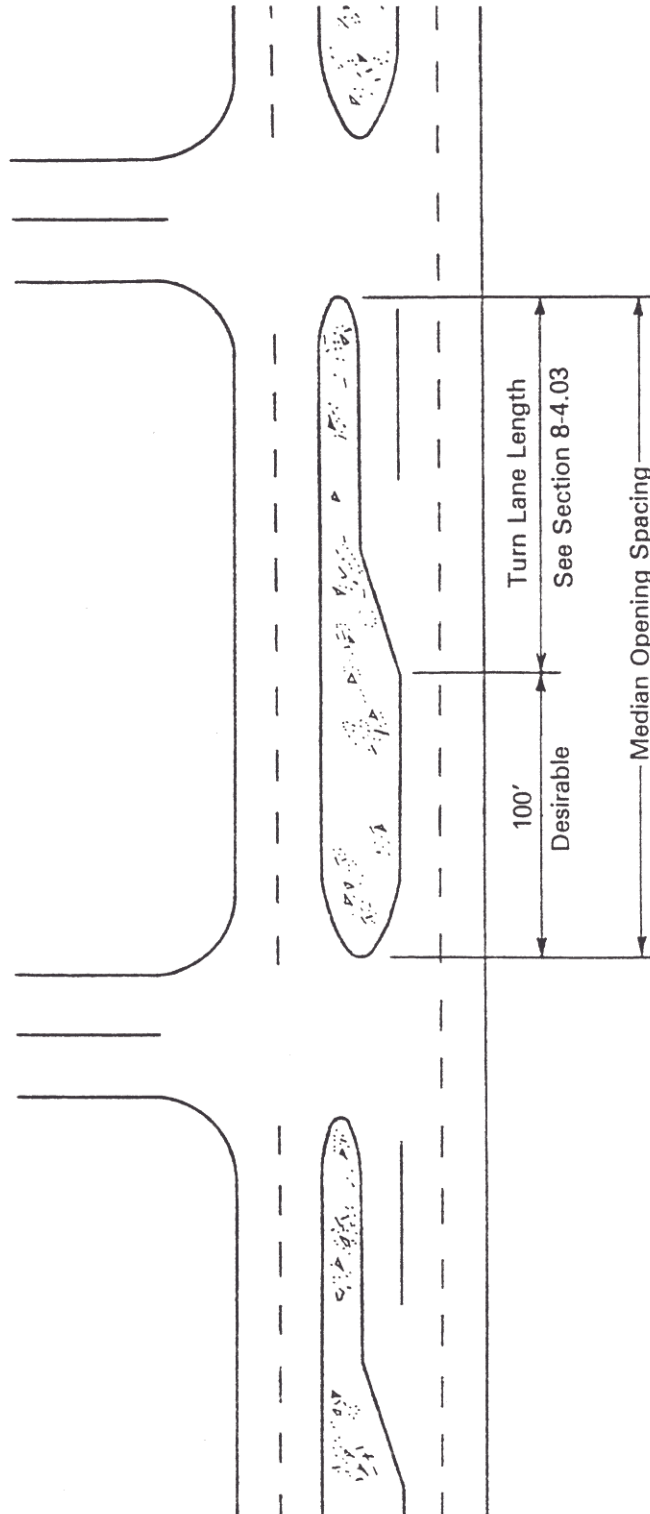
Desirably, median openings will be provided on divided non-freeways at all public roads and major traffic generators (e.g., shopping centers). In urban areas, this may result in close intersection spacing which impairs the operation of the facility. The following should be evaluated when determining the warrant for a median opening on urban arterials:

1. **Signalized Intersections**. Signalized intersections should be no more closely spaced than 1600 feet. Closer spacings may impair the operation of the signals.
2. **Unsignalized Intersections**. Median openings at unsignalized intersections will depend upon two factors. The width of the median should allow the development of an exclusive left-turn lane; if not, it may be practical to widen the median at the intersection to provide space for a channelized left-turn lane. The spacing of median openings should be large enough to allow the development of an exclusive left-turn lane with the proper length. See Figure 8-23.

Freeways

On fully access-controlled freeways, crossovers are needed to accommodate maintenance and emergency vehicles. The following should be considered:

1. **Warrants and Location**. Crossovers should be placed to facilitate operations such as snow plowing and considering interchange spacing. The decision on warrants and locations will be made by the Bureau of Maintenance and Operations.
2. **Sight Distance**. Because of the unexpected U-turn maneuver, sight distances should be high when vehicles make U-turns on freeways. At a minimum, the sight distance should be 1500 feet to the crossover from both directions.
3. **Median Barriers**. Emergency crossovers should be avoided where a median barrier is present. If a crossover must be provided, the barrier should be terminated as described in Section 10-6. The width of the opening should be approximately 25-30 feet



**RECOMMENDED MEDIAN OPENING SPACING
(Non-Freeways)**

Figure 8-23

**RECOMMENDED MEDIAN OPENING SPACING
(Non-Freeways)**

Figure 8-23

8-6.02 Design

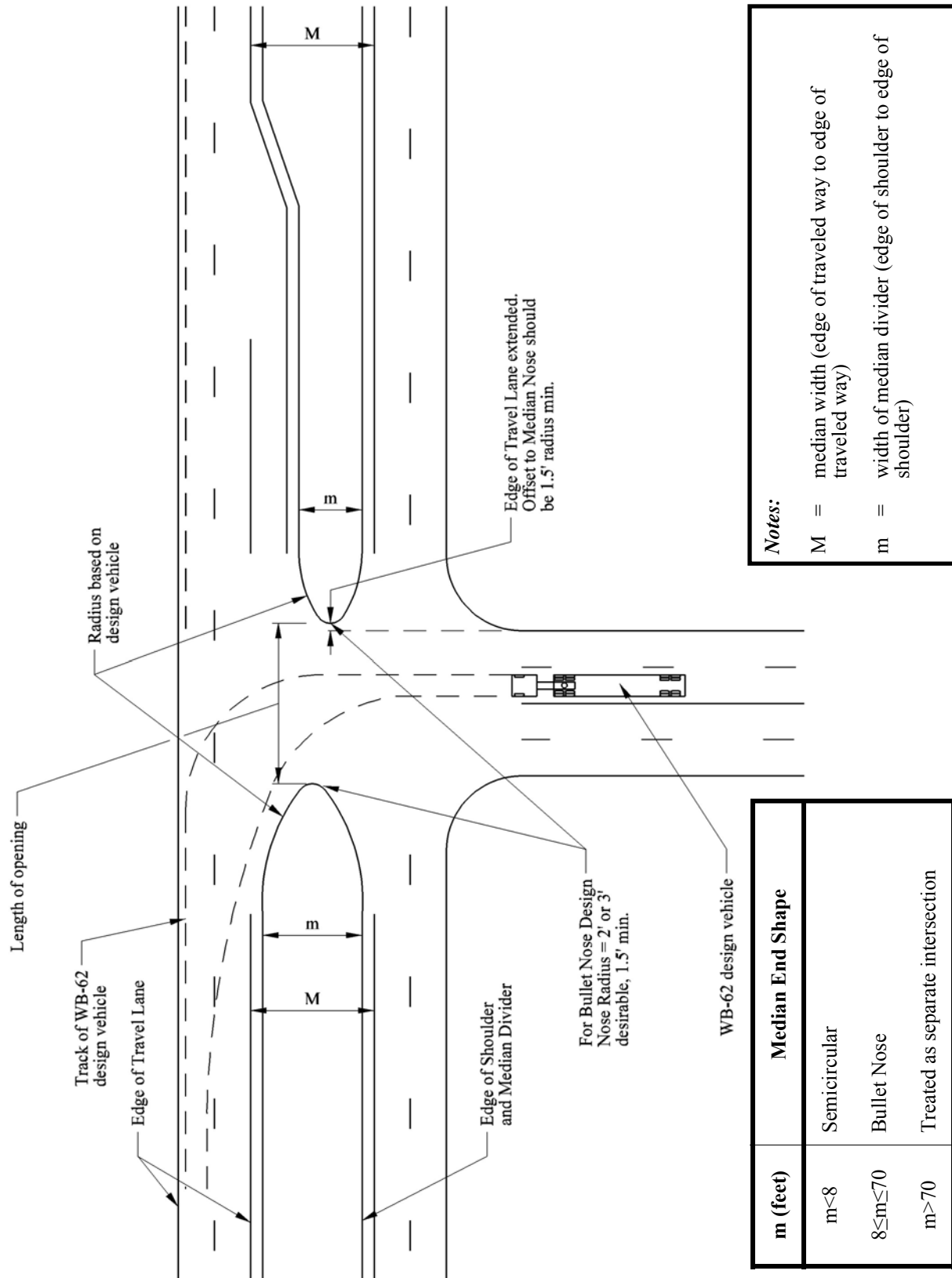
Figure 8-24 illustrates the turning path for the WB-62 design vehicle, and it illustrates other design criteria at a median opening. The following will apply:

1. **Design Vehicle**. The WB-62 design vehicle will apply to median openings.
2. **Encroachment**. Where a single left-turn lane is used, the desirable design will be to allow the WB-62 to make the left-turn entirely within the inside lane; i.e., there will be no encroachment into the through lane adjacent to the inside lane. It will be acceptable for the WB-62 to occupy both travel lanes in its turn (see Figure 8-23).
3. **Median Nose Design**. The shape of the nose at median openings depends on the width of the divider (m) either between the two roadway edges or between the left-turn lane and the opposing roadway edge (see Figure 8-23). This width is in contrast to the median width (M), which is measured between the edges of the two inside lanes and, therefore, includes the width of left-turn lanes, if present, and shoulder/curb offset widths.

The most common types of median noses are the semicircular end and the bullet-nose end. Recommended criteria for the selection of the median end shape based on " m " are provided in Figure 8-24. Although the semicircular design may be used for wider medians, this requires considerably larger lengths of openings.

For the bullet-nose design, a compound curvature arrangement should be used. The radius at the tip of the nose will normally be 2-3 feet with a minimum of 1.5 feet. To determine the flatter radius, the designer should use the turning template of the design vehicle. The designer should then select a nose radius which allows the design vehicle to make the turn while at no time coming closer than 2 feet to the radius line.

4. **Length of Opening**. The length of a median opening should properly accommodate the turning path of the design vehicle. The minimum length is 40 feet. The length of opening should be at least 4 feet greater than the width of the intersecting road. Each median opening will be evaluated individually to determine the proper length of opening. The designer should consider the following factors in the evaluation:
 - a. **Turning Templates**. The WB-62 will be used to check the length of opening.
 - b. **Inside Clearance**. As stated in No. 3, the WB-62 design vehicle should make the turn without coming closer than 2 feet to the median nose



MEDIAN OPENING DESIGN

Figure 8-24

MEDIAN OPENING DESIGN

Figure 8-24

- c. Lane Alignment. The designer should ensure that lanes line up properly for crossing traffic.
- d. Location of Crosswalks. Desirably, pedestrian crosswalks will intersect the median nose to provide some refuge for pedestrians. Crosswalk location will be coordinated with the Traffic Engineering Division

8-7 CHANNELIZED ISLANDS

Several of the treatments described in this chapter require channelized islands within the intersection areas. These include turning roadways and channelized left-turn lanes. Figure 8-25 illustrates a typical channelization treatment as a T-intersection. Figure 8-26 illustrates several types of channelized islands with the key details for island design. These are discussed in the following sections.

8-7.01 Types of Islands

1. **Directional Islands**. Directional islands (e.g., for turning roadways) control and direct traffic movements and guide the driver into the proper channel.
2. **Divisional Islands**. Divisional islands separate opposing traffic flows, alert the driver to the crossroad ahead and regulate traffic through the intersection. These islands are often introduced at intersections on undivided highways. The minimum length of divisional islands is 25 feet.

Channelized islands may be some combination of flush or raised, paved or grass, and triangular or elongated. Raised islands formed by curbs should be used where pedestrian traffic is significant, where traffic control devices are needed within the island, and where the design speed is 45 mph and below.

8-7.02 Minimum Size

Figure 8-26 indicates minimum sizes for channelized islands.

8-7.03 Delineation/Approach Treatment

Channelized islands should be delineated by sloping curb or pavement markings based on their size, location and function.

Angle of Intersection	R_1	R_2
60°	1000'	150'
70°	720'	240'
80°	720'	520'
90°	720'	720'
100°	480'	440'
110°	440'	720'
120°	400'	500'

Gravel Shoulder

Shoulder

10 x Shoulder Width

Paved Shoulder

Full-Depth Pavement

R_1

R_2

PC

PT

Side Road

Curbed Island as Designated

Sloping Curb

R as Required by WB-62

Shoulder Width + 2'

ETL

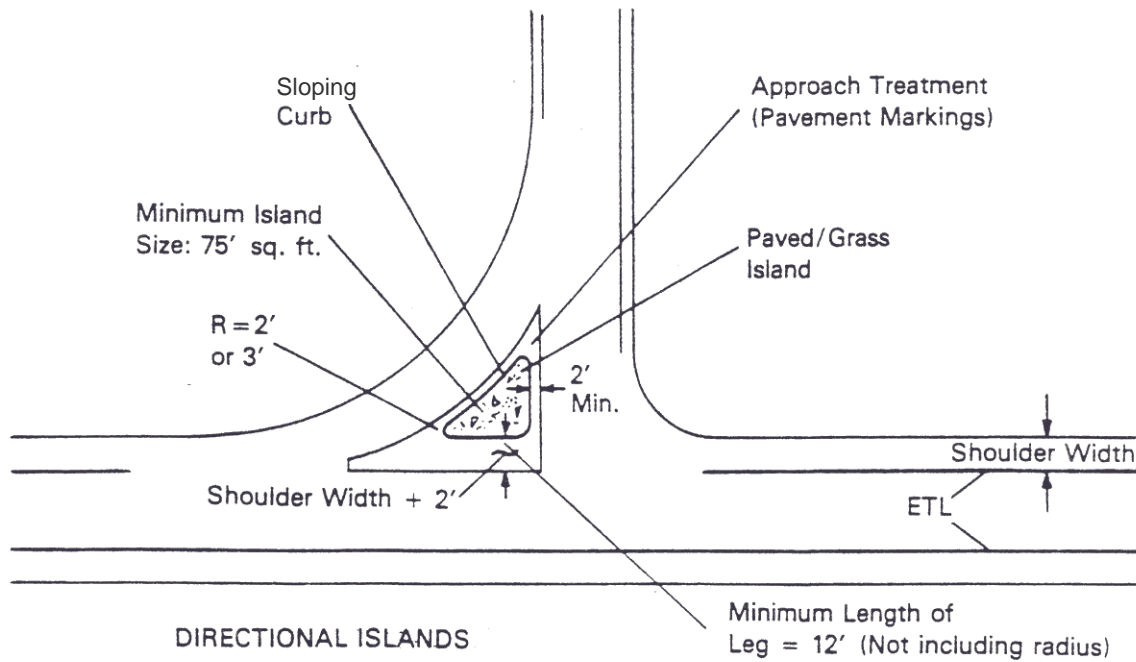
$R = 5'$

Angle of Intersection Between the Two Centerlines

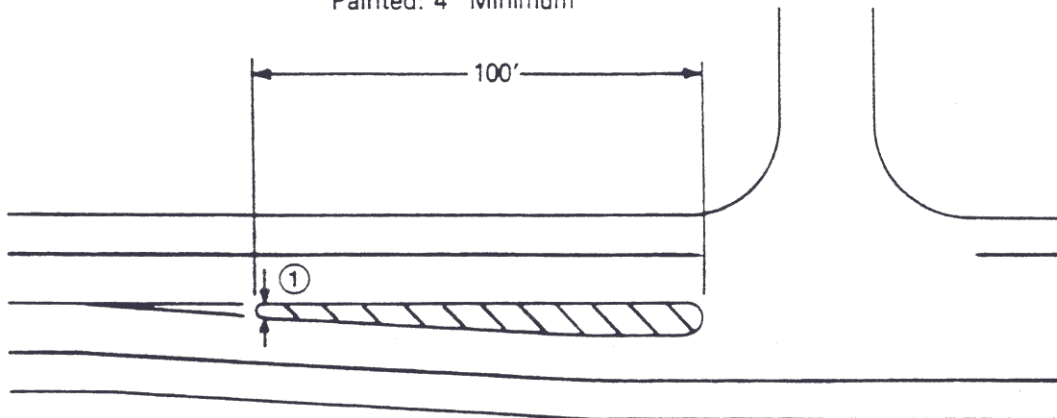
- Figure 8-25**

December 2004

CHANNELIZED ISLANDS



- ① Dimensions as follows:
- Curbed: 4' Minimum
 - Concrete Flush: 2' Minimum
 - Painted: 4' Minimum



CHANNELIZED ISLANDS

Figure 8-26

8-8 ENTRANCE DESIGN

8-8.01 Design Criteria

Entrance Types (Definitions)

1. Residential. One providing access to a single-family residence or 1-4 residential units.
2. Commercial/Industrial. One providing access to an office, retail or institutional building, to an apartment building or to a warehouse, truck terminal, etc. Such buildings are customarily serviced by trucks. A centralized retail development, such as a community or regional shopping center, may have one or more driveways especially designed, signed and located to provide access for trucks. These also are classified as commercial/industrial entrances.

Entrance Sight Distance

Section 8-1 discusses intersection sight distance (ISD) criteria for intersections with public roads. Desirably, these criteria will also apply to sight distances at entrances. For entrances with low volumes, it is not warranted to explore extraordinary measures to improve sight distance. The designer should check for sight obstructions in the vicinity of the entrance such as large trees or hedgerows. To perform the check, it is reasonable to assume an eye location of approximately 10 feet from the edge of travel lane.

Auxiliary Lanes

Deceleration and acceleration lanes should be considered at high-volume entrances, especially on high-speed, high-volume arterials. Section 8-4 further discusses the design and warrants for auxiliary lanes, and these also apply to high-volume entrances. In addition to traffic-volume considerations, it may be warranted to provide a right-turn lane into the entrance if the change in grade is abrupt at the entrance.

Side Slopes

Driveway side slopes should be the same as the mainline side slope. This applies for a minimum distance of the roadside clear zone for the mainline. Beyond this point, driveway side slopes may be steeper.

Material

During the preliminary or final field inspection, the Construction Team Member may designate if the project being inspected is in an area of the State where the available gravel is sandy and difficult to compact for a good driving surface. Should this be the case, the designer will select the entrance note that calls for gravel entrances to be constructed of 11 inch Aggregate Subbase Course-Gravel and 3 inch Untreated Aggregate Surface Course and estimate accordingly. This note will be added to the general notes.

Drainage

At some entrances, the potential may exist for melting water to flow along snowbanks and down the entrance toward a building. To alleviate this, the designer will include a hump at the edge of shoulder for all entrances under these conditions whether or not a curb is present. The design of this hump will be according to the Standard Details. This design may be omitted or modified if excessive right-of-way damage is caused by it or if there is no potential drainage problem. Also, it is not intended for use on undeveloped properties that are served by woods and field entrances

Design Vehicle

The following design vehicles apply:

1. **Residential Entrances**. Use the P design vehicle.
2. **Commercial/Industrial Entrances**. Use the WB-62 design vehicle.

The application of a turning template will determine the combination of width and turning radii into the entrance which will accommodate the design vehicle.

Grades at Skewed Entrances

When designing skewed drives, the grade shown is usually along the centerline of the drive. When the skew is sufficiently large, this causes the grade along the inside edge to be considerably steeper than that shown along the centerline and, in a number of cases, will require the resident to lengthen and regrade the entrance. The designer should show grades along the inside edge of all drives that are skewed 30 degrees or more. The inside edge is that edge that forms an acute angle with the roadway. This policy should avoid needing additional grading rights and determining more accurately whether or not a drive should be paved or not because of percent grade.

8-8.02 Entrance Figures**Typical Entrance Profiles**

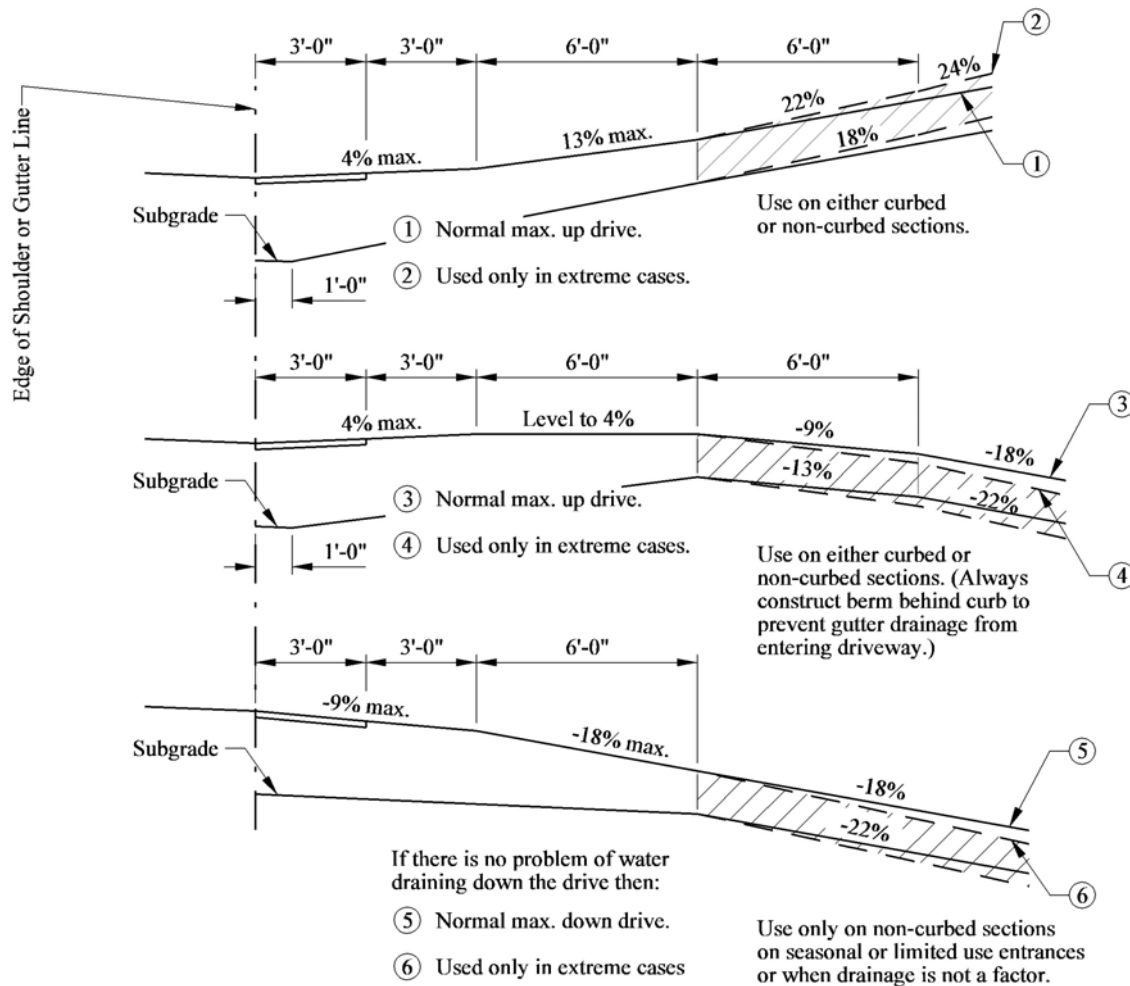
Figure 8-27 presents design criteria for entrances where no sidewalks exist; Figure 8-28 applies to entrances where sidewalks are present.

Typical Entrance Plan Views

Typical plan views of entrances are:

1. Figure 8-29 "Residential Entrance onto Uncurbed Highway (Gravel Shoulders)."
2. Figure 8-30 "Residential Entrance onto Uncurbed Highway (Paved Shoulders)."
3. Figure 8-31 "Commercial/Industrial Entrance onto Uncurbed Highway (Gravel Shoulders)."
4. Figure 8-32 "Commercial/Industrial Entrance onto Uncurbed Highway (Paved Shoulders)."
5. Figure 8-33 "Commercial/Industrial Double Entrances onto Uncurbed Highway (Gravel Shoulders)."
6. Figure 8-34 "Commercial/Industrial Double Entrances onto Uncurbed Highway (Paved Shoulders)."

7. Figure 8-35 "Corner Lot Entrance onto Rural Highway
8. Figure 8-36 "Shopping Center Entrance onto Highway (Paved Shoulders)."
9. Figure 8-37 "Residential Entrance onto Curbed Highway (With/Without Sidewalks)."
10. Figure 8-38 "Commercial/Industrial Entrance onto Curbed Highway (With/Without Sidewalk)."
11. Figure 8-39 "Commercial/Industrial Entrance onto Curbed Highway (Curbed Entrance)."
12. Figure 8-40 "Commercial/Industrial Double Entrances onto Curbed Highway (Narrow Right-of-Way)."
13. Figure 8-41 "Commercial/Industrial Double Entrances onto Curbed Highway (Wide Right-of-Way)."
14. Figure 8-42 "Corner Lot Entrance onto Urban Highway (Narrow Right-of-Way)."

**General Notes:**

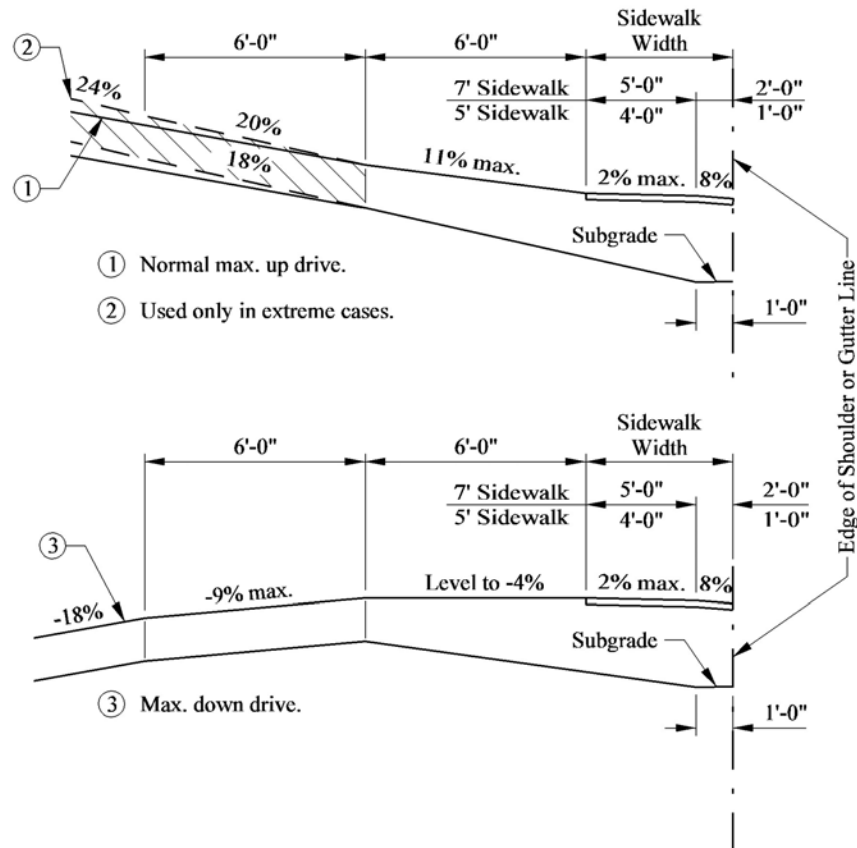
- ① The first 3 feet shown as pavement will be paved only when abutting a paved shoulder to a non-paved entrance.
- ② All residential or commercial drives 10% and over will be paved.

Notes on Maximum Driveway Profiles:

- ① These profiles are a guide for the majority of cases, but should be field checked when the main line grade is steep (4% to 6% or greater) or the angle of approach to the drive is unusual.
- ② Generally the majority of drives on a project will be built with flatter profiles than these maximum cases.
- ③ When grading drives which are flatter than the maximum profiles the following rule of thumb should be used: Do not exceed a grade % change of more than 9% in a 6-foot increment of driveway length. This applies to both up and down profiles.

TYPICAL ENTRANCE PROFILE (No Sidewalk)

Figure 8-27

**General Notes:**

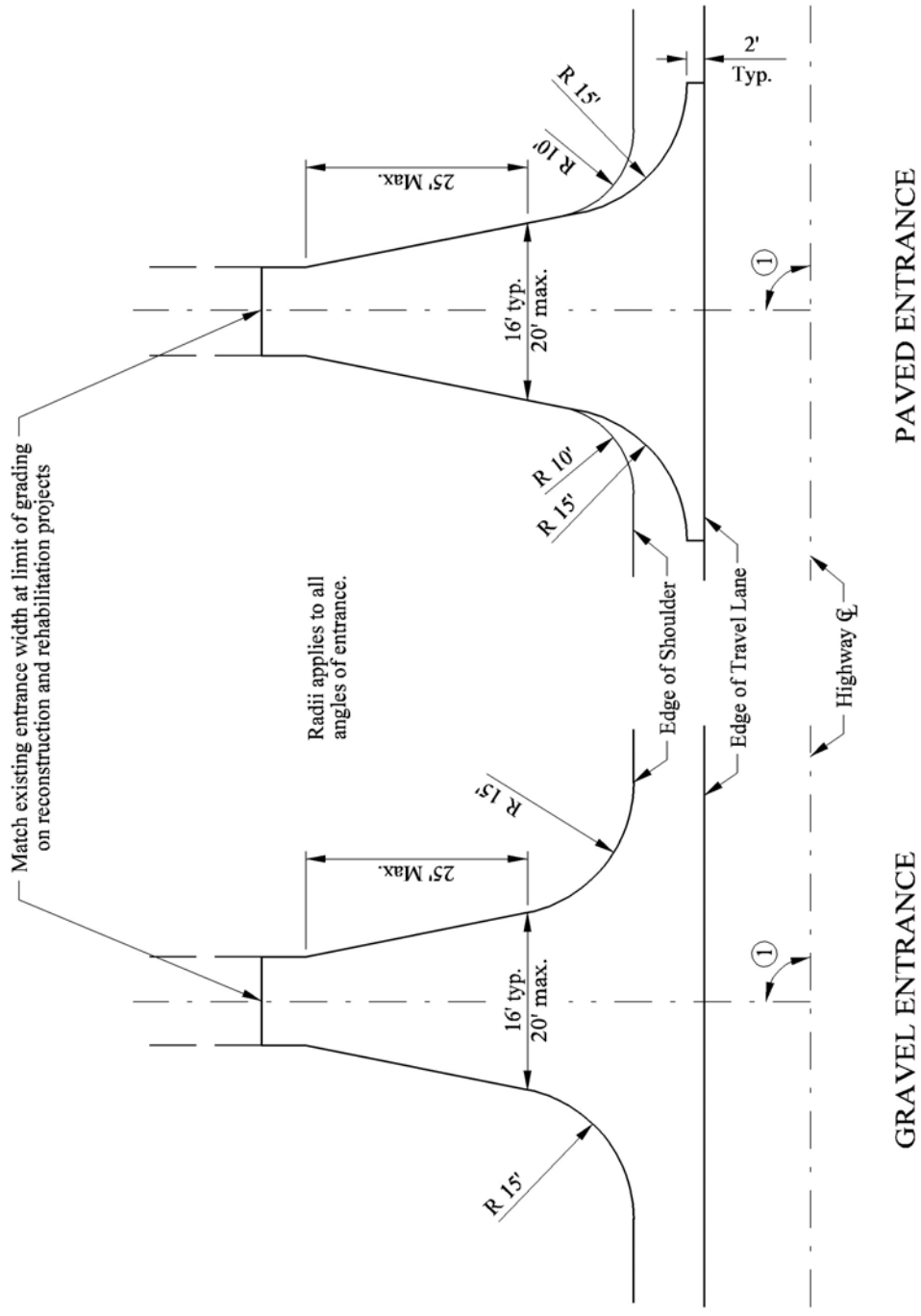
- ① The sidewalk width will be paved in all cases.
- ② All residential or commercial drives 10% and over will be paved.

Notes on Maximum Driveway Profiles:

- ① These profiles are a guide for the majority of cases, but should be field checked when the main line grade is steep (4% to 6% or greater) or the angle of approach to the drive is unusual.
- ② Generally the majority of drives on a project will be built with flatter profiles than these maximum cases.
- ③ When grading drives which are flatter than the maximum profiles the following rule of thumb should be used: Do not exceed a grade % change of more than 9% in a 6-foot increment of driveway length. This applies to both up and down profiles.

TYPICAL ENTRANCE PROFILE (Sidewalk)

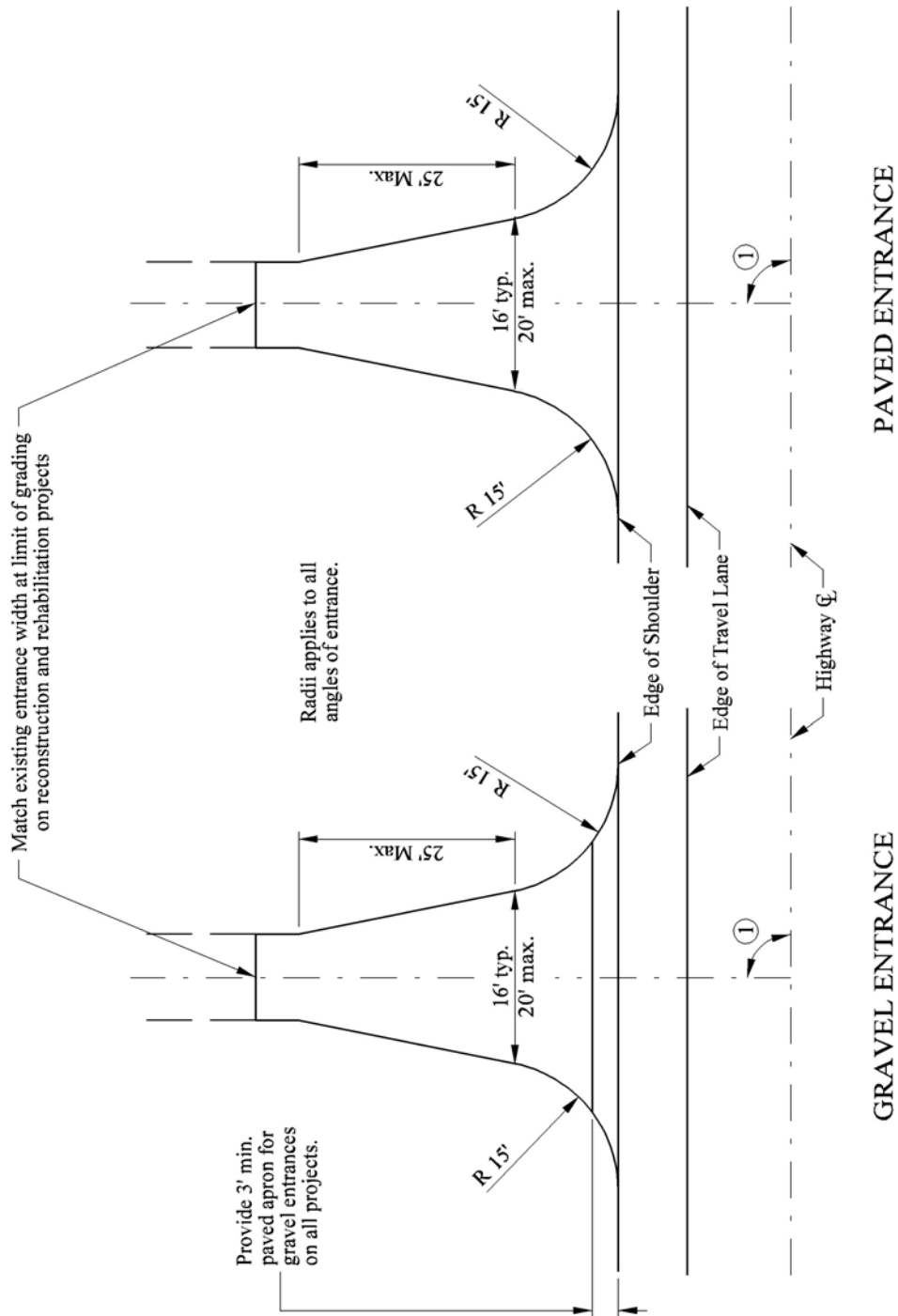
Figure 8-28



**RESIDENTIAL ENTRANCE ONTO UNCURBED HIGHWAY
(Gravel Shoulders)**

**RESIDENTIAL ENTRANCE ONTO UNCURBED HIGHWAY
(Gravel Shoulders)**

Figure 8-29

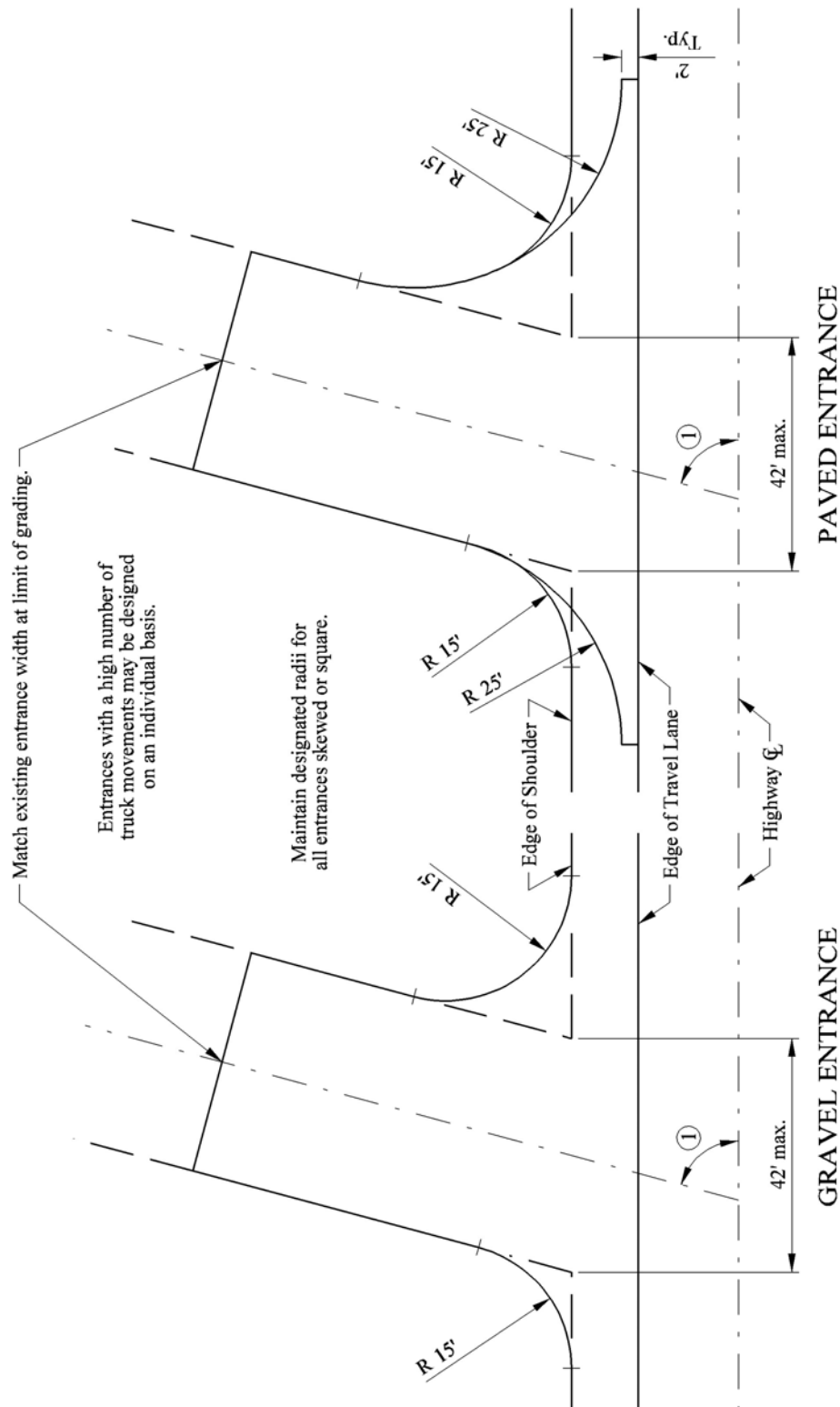


**RESIDENTIAL ENTRANCE ONTO UNCURBED HIGHWAY
 (Paved Shoulders)**

Figure 8-30

**RESIDENTIAL ENTRANCE ONTO UNCURBED HIGHWAY
 (Paved Shoulders)**

Figure 8-30

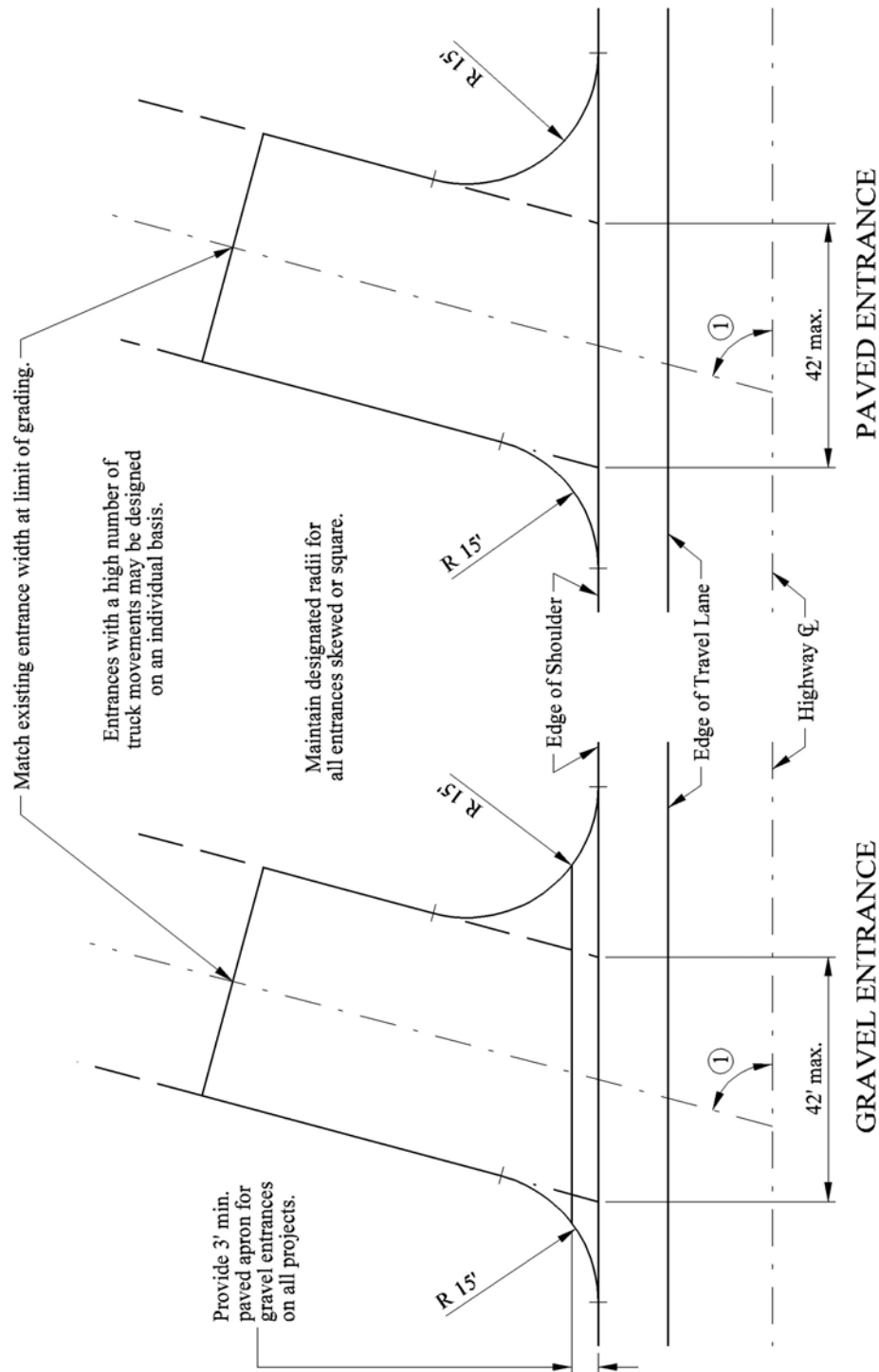


COMMERCIAL/INDUSTRIAL ENTRANCE ONTO UNCURBED HIGHWAY
(Gravel Shoulders)

Figure 8-31

COMMERCIAL/INDUSTRIAL ENTRANCE ONTO UNCURBED HIGHWAY
(Gravel Shoulders)

Figure 8-31

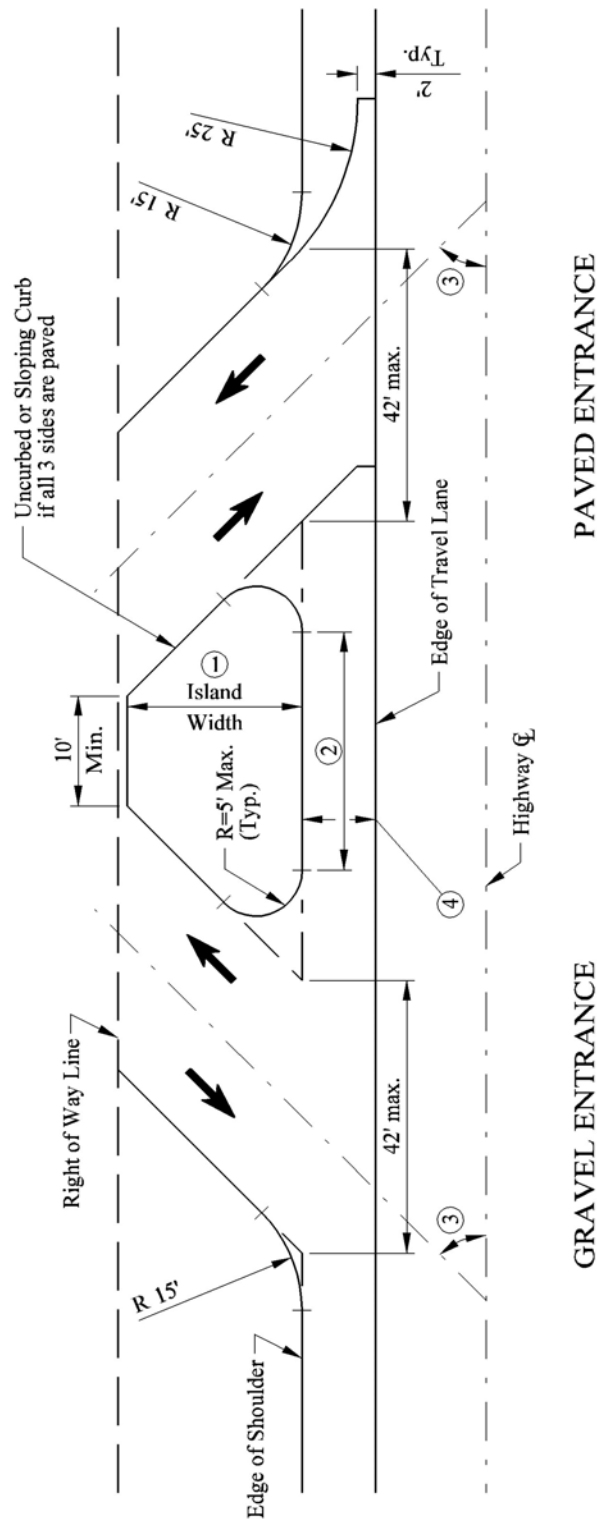


**COMMERCIAL/INDUSTRIAL ENTRANCE ONTO UNCURBED HIGHWAY
(Paved Shoulders)**

Figure 8-32

**COMMERCIAL/INDUSTRIAL ENTRANCE ONTO UNCURBED HIGHWAY
(Paved Shoulders)**

Figure 8-32

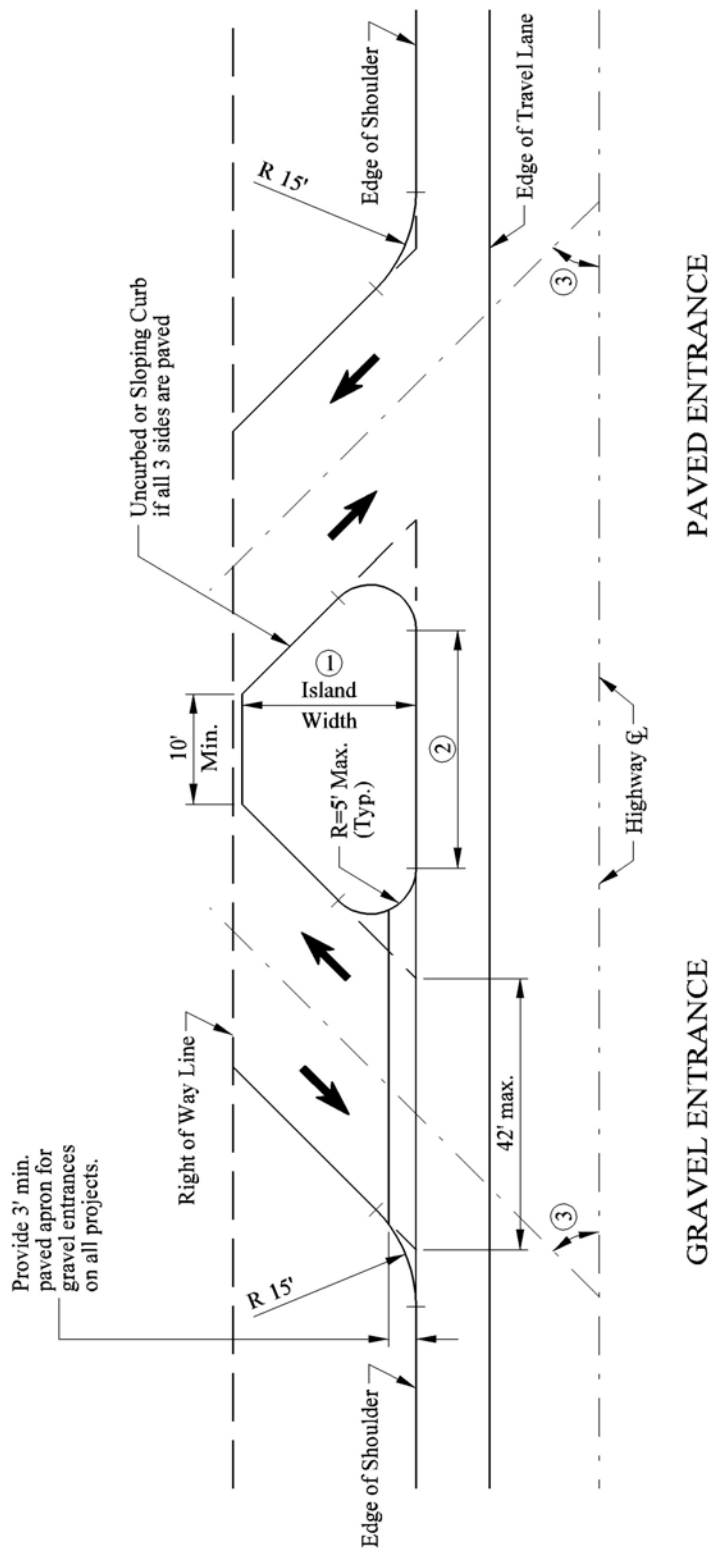


**COMMERCIAL/INDUSTRIAL DOUBLE ENTRANCE ONTO UNCURBED HIGHWAY
(Gravel Shoulders)**

Figure 8-33

**COMMERCIAL/INDUSTRIAL DOUBLE ENTRANCES ONTO UNCURBED HIGHWAY
(Gravel Shoulders)**

Figure 8-33

**Notes:**

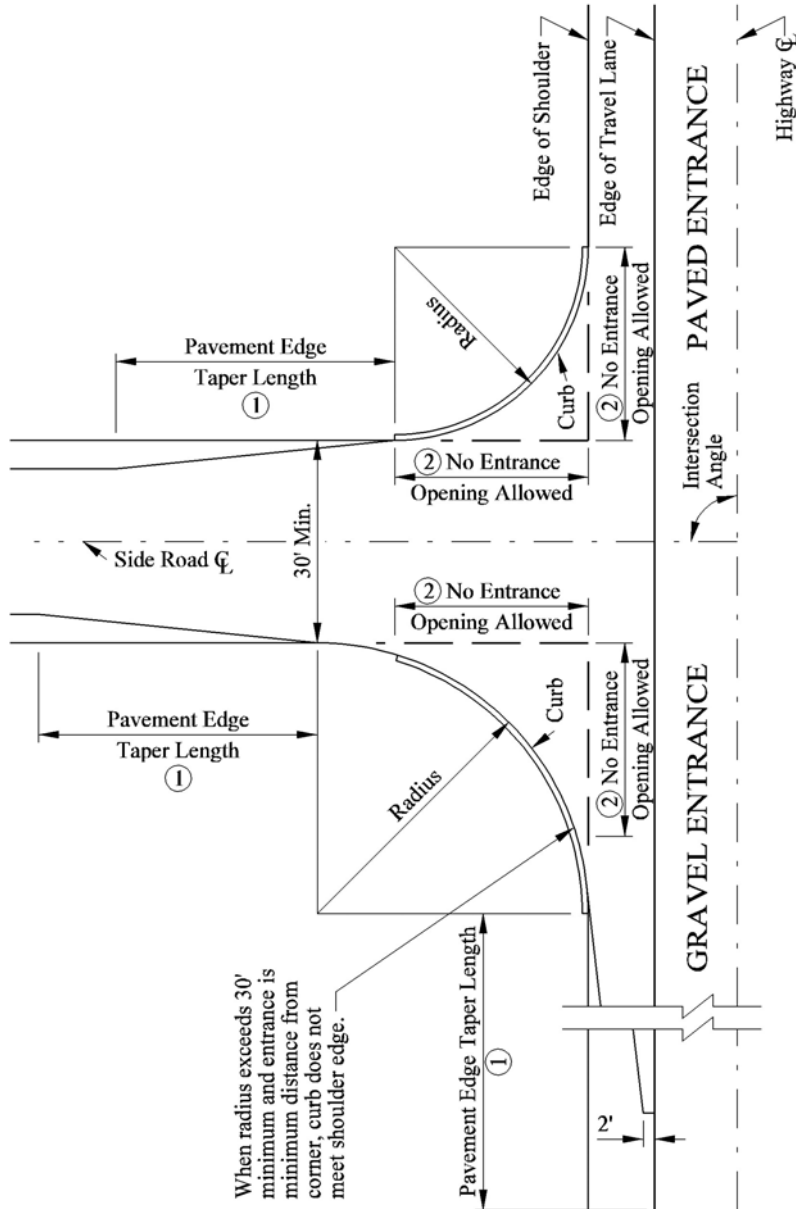
- ① Island width to extend within 1'-0" of right-of-way line, if practical.
- ② Island length to be determined by island width and entrance angle. Length will be in multiple of 4. Minimum length will be 12'.
- ③ Entrance angle should not be less than 45°.
- ④ This is shoulder width/curb offset. In rural areas, if a 4' or 6' shoulder is on the mainline, this should be increased by 2' at the island. An 8' or 10' shoulder need not be increased.

**COMMERCIAL/INDUSTRIAL DOUBLE ENTRANCES ONTO UNCURBED HIGHWAY
(Paved Shoulders)**

Figure 8-34

**COMMERCIAL/INDUSTRIAL DOUBLE ENTRANCES ONTO UNCURBED HIGHWAY
(Paved Shoulders)**

Figure 8-34

**Notes:**

- ① Where there are gravel shoulders, pavement edge should be tapered for a minimum distance of 10 x the shoulder width.
- ② This dimension will be determined as follows:

<u>Intersection</u>	<u>Distance</u>
90°	30'
85°	33'
80°	36'
75°	39'
70°	43'
65°	47'
60°	52'

In addition, entrances on the approach side of stop or signal control should not be located within the storage length (L_s). See Section 8-4.

CORNER LOT ENTRANCE ONTO RURAL HIGHWAY

Figure 8-35

CORNER LOT ENTRANCE ONTO RURAL HIGHWAY

Figure 8-35

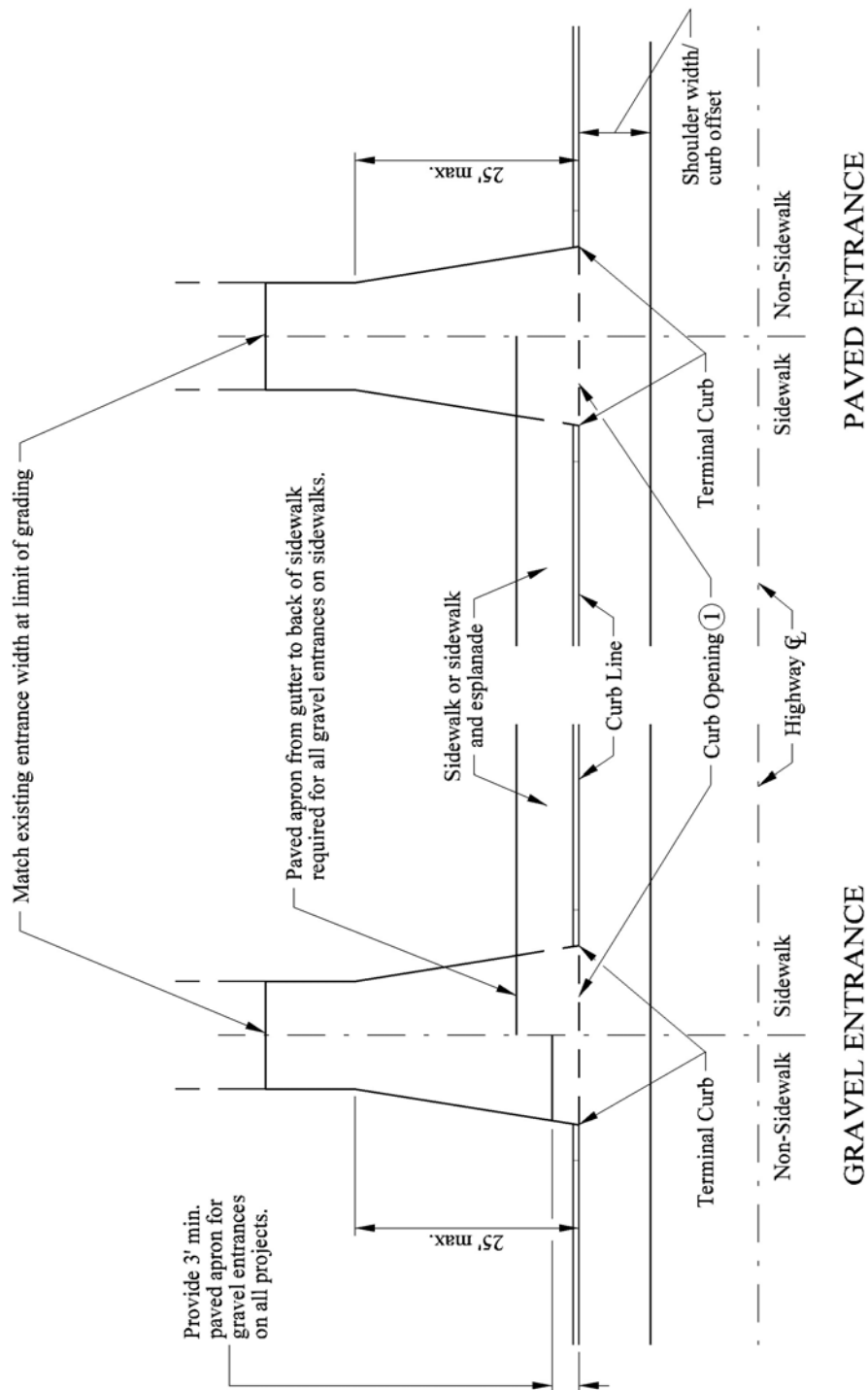


② All island borders shall be curbed.

SHOPPING CENTER ENTRANCE ONTO HIGHWAY (Paved Shoulders)

Figure 8-36

Figure 8-36



Note:

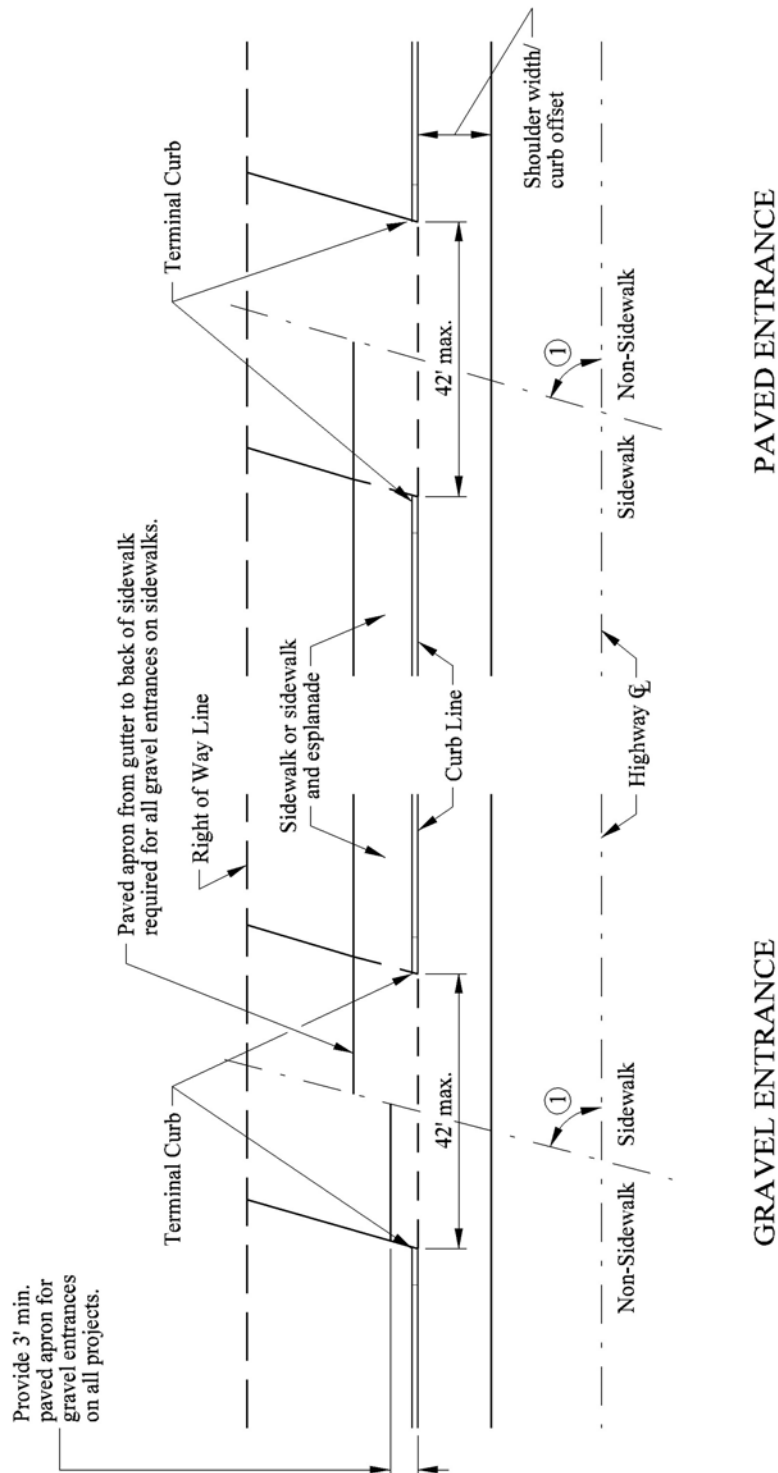
- ① Curb opening is 20' where the shoulder width $\geq 6'$ and 26' where the shoulder width $< 6'$

**RESIDENTIAL ENTRANCE ONTO CURBED HIGHWAY
(With/Without Sidewalks)**

Figure 8-37

**RESIDENTIAL ENTRANCE ONTO CURBED HIGHWAY
(With/Without Sidewalks)**

Figure 8-37

**Note:**

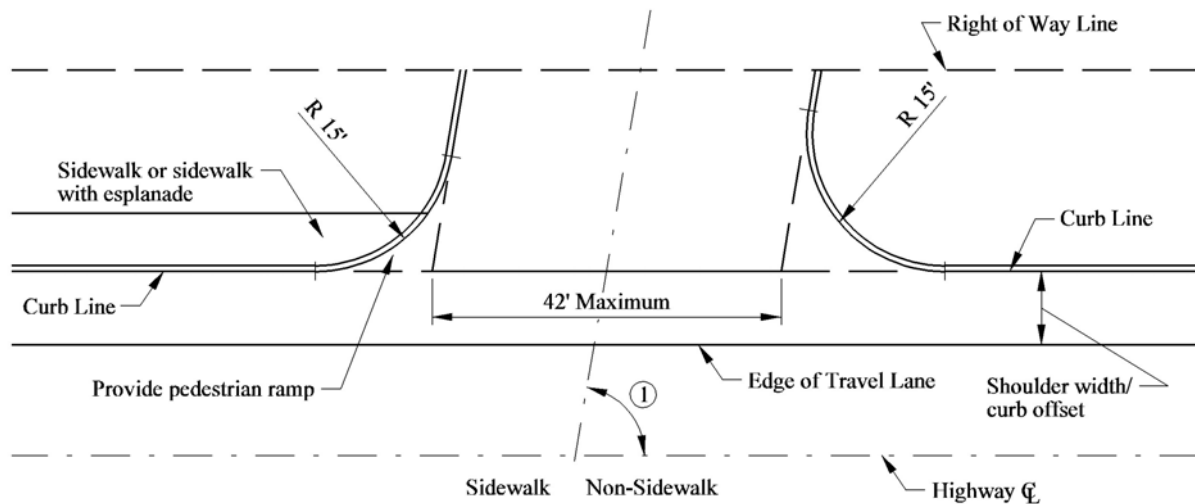
- ① Minimum entrance angle is 45° where the shoulder width $\geq 6'$ and 60° where the shoulder width $< 6'$.
- ② If there are high truck turning volumes, the designer should consider providing turning radii of 15' - 25' and/or a wider opening and/or limiting the angle of turn to accommodate trucks.

COMMERCIAL ENTRANCE ONTO CURBED HIGHWAY
(With/Without Sidewalks)

Figure 8-38

COMMERCIAL/INDUSTRIAL ENTRANCE ONTO CURBED HIGHWAY
(With/Without Sidewalks)

Figure 8-38



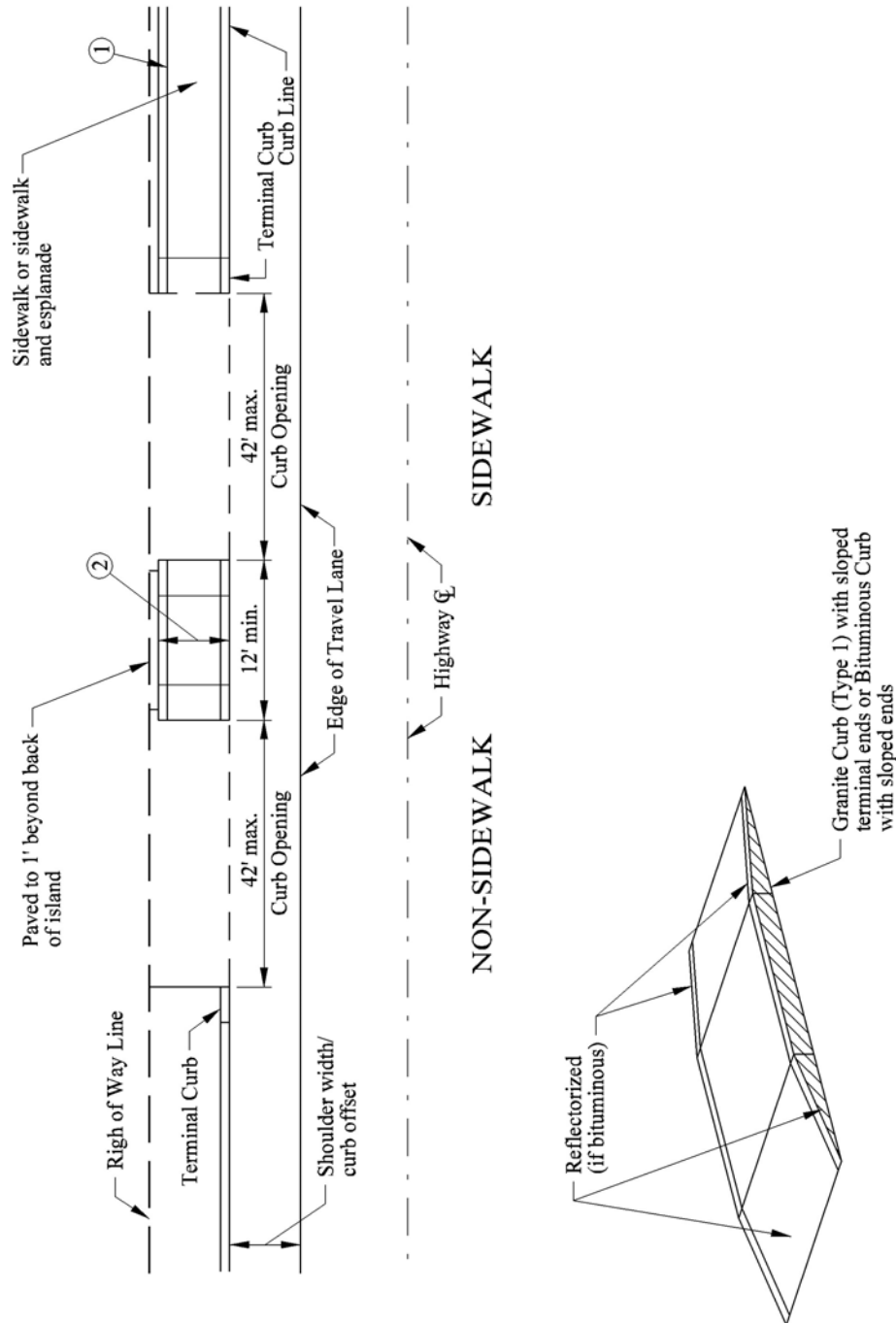
PAVED ENTRANCE

Note:

- ① Minimum entrance angle is 45° where the shoulder width $\geq 6'$ and 60° where the shoulder width $< 6'$

**COMMERCIAL/INDUSTRIAL ENTRANCE ONTO CURBED HIGHWAY
(Curbed Entrance)**

Figure 8-39

**Note:**

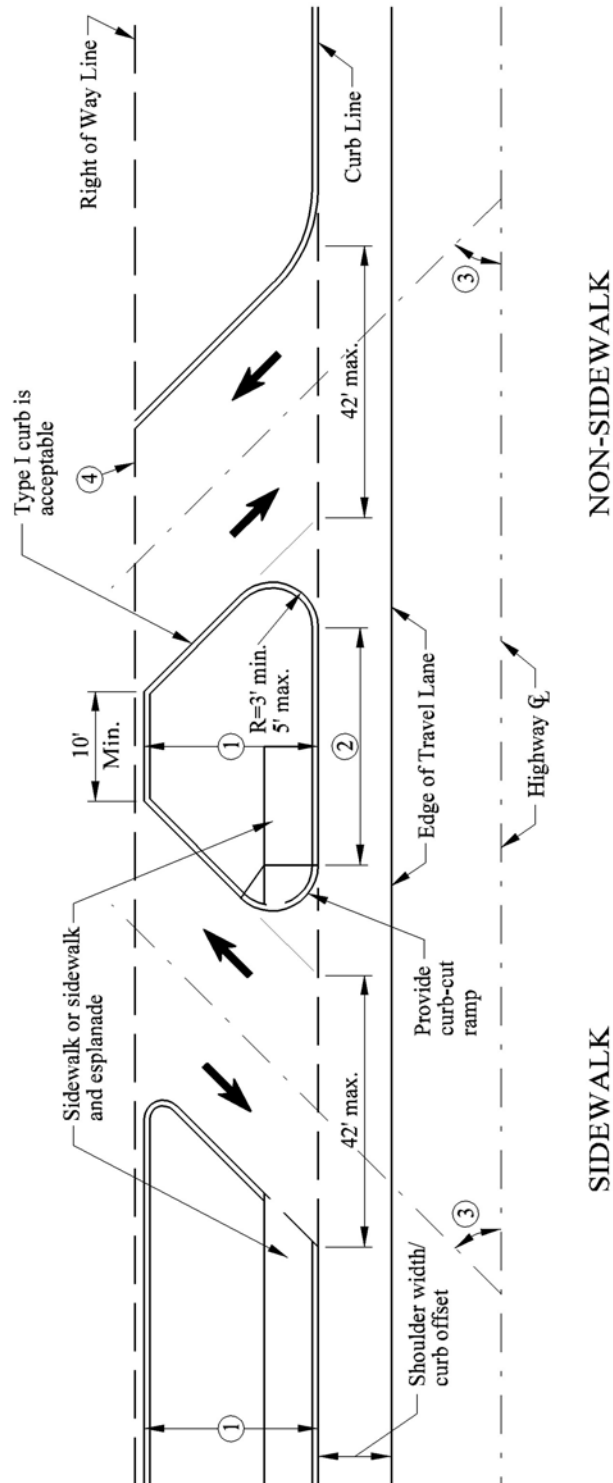
- ① Where parking of service area abuts sidewalk, a curb, guardrail or fence should be provided.
- ② Island width will extend within 1' of right-of-way line, if practical. When island width exceeds 10', use design in figure 8-41.
- ③ If there are high truck turning volumes, the designer should consider providing turning radii of 15' - 25' and/or wider opening and/or limiting the angle of turn to accommodate trucks.

**COMMERCIAL/INDUSTRIAL DOUBLE ENTRANCE ONTO CURBED HIGHWAY
(Narrow Right-of-Way)**

Figure 8-40

**COMMERCIAL/INDUSTRIAL DOUBLE ENTRANCE ONTO CURBED HIGHWAY
(Narrow Right-of-Way)**

Figure 8-40

Note:

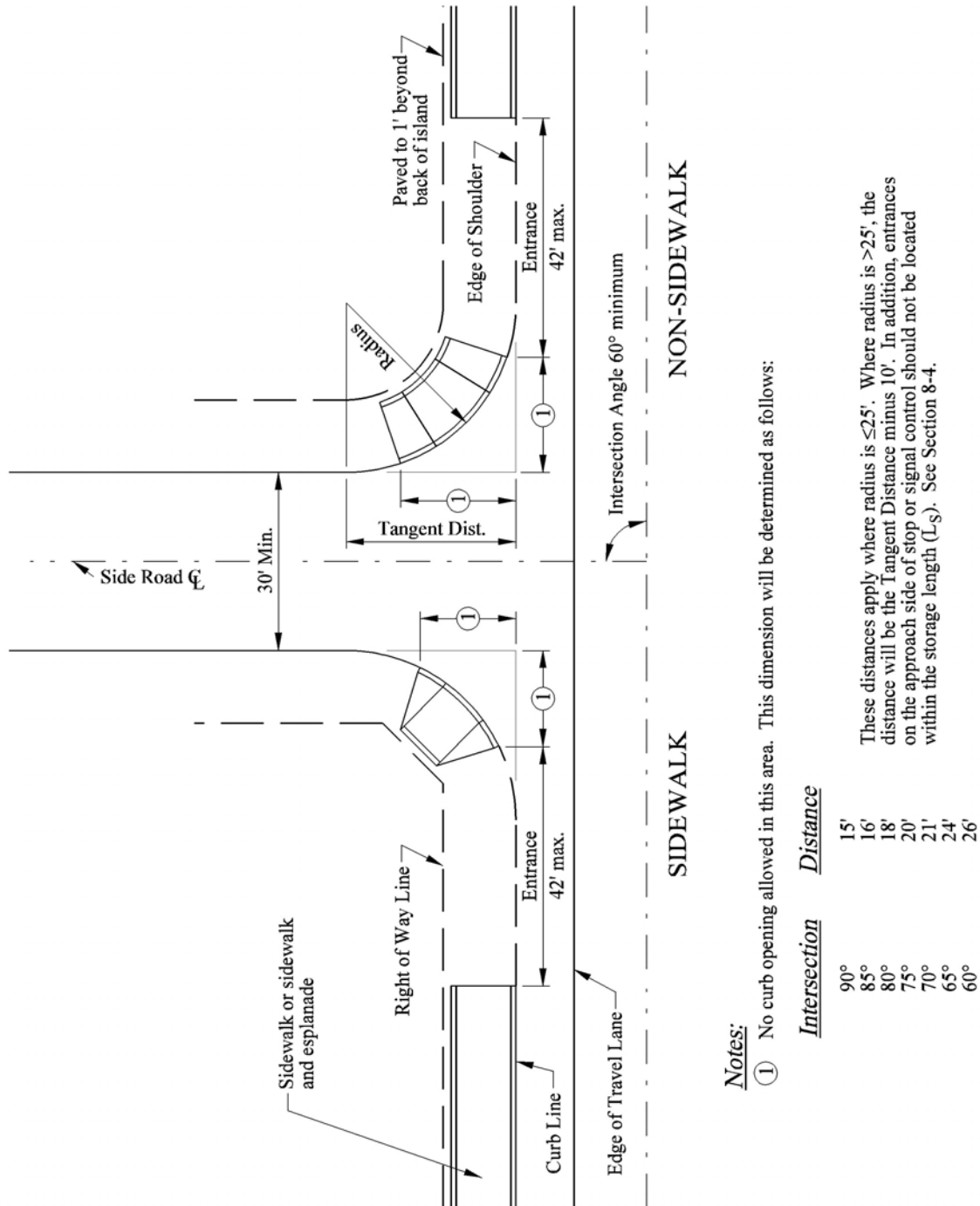
- ① Island width will extend within 1' of right-of-way line, if practical.
- ② Use 12' for non-sidewalk and 20' for sidewalk minimum for this dimension. Length should always be a multiple of 4'.
- ③ Entrance angle should not be less than 45°.
- ④ Where gravel entrances are present, the entrance should be paved to 1' beyond back of island.

**COMMERCIAL/INDUSTRIAL DOUBLE ENTRANCES ONTO CURBED HIGHWAY
(Wide Right-of-Way)**

Figure 8-41

**COMMERCIAL/INDUSTRIAL DOUBLE ENTRANCE ONTO CURBED HIGHWAY
(Wide Right-of-Way)**

Figure 8-41



**CORNER LOT ENTRANCE ONTO URBAN HIGHWAY
(Narrow Right-of-Way)**

Figure 8-42

**CORNER LOT ENTRANCE ONTO URBAN HIGHWAY
(Narrow Right-of-Way)**

Figure 8-42

8-9 ALIGNMENT / PROFILE

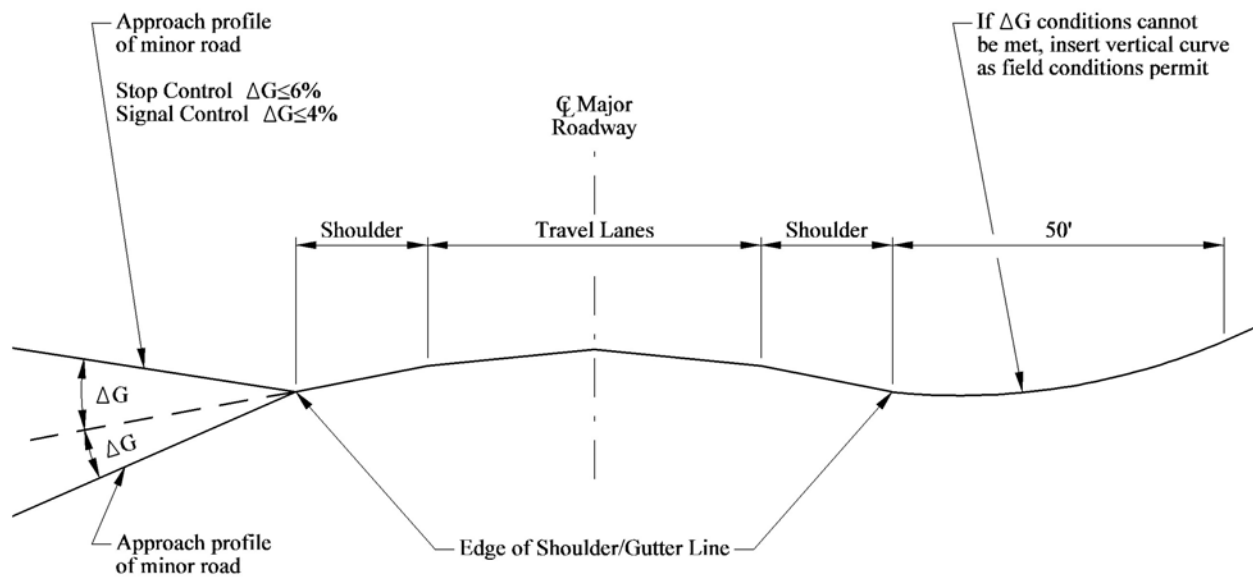
8-9.01 Alignment

The angle of intersection should be within 30 degrees of a 90-degree intersection. Skewed intersections beyond 30 degrees increase the travel distance across the major highway, adversely affect sight distance and complicate the designs for turning movements. If the angle of intersection is not within 30 degrees of a right angle, the intersection should be realigned to 90 degrees, if practical.

8-9.02 Profile

Figure 8-43 illustrates profile considerations. The following will apply:

1. **Approaching Gradient.** The area where vehicles may store on the leg of an intersection should be as flat as practical. The grade on this landing area (or storage platform) should not exceed 2%, if practical.
2. **Stop-Controlled.** The profile and cross section of the major road will normally be maintained through the intersection. The cross section of the stop-controlled road will be transitioned (or warped) to match the major road. The change in gradient on the stop-controlled leg at its entrance into the intersection should not exceed 6%. If it does, the designer should insert a vertical curve approximately 50 feet long to transition from the grade on the minor road to meet the cross slope on the major road.
3. **Signal-Controlled.** The most desirable option will be to transition all approach legs into a plane section through the intersection. This will ensure that the vehicles that pass through the intersection will not "bottom out." This may be especially appropriate for arterial/arterial intersections. If this option is not practical, the designer should transition one road to meet the profile and cross section of the other road. The change in gradient on the transitioned leg at its entrance into the intersection should not exceed 4%. If it does, the designer should insert a vertical curve approximately 50 feet long to transition from the grade on the minor road to meet the cross slope on the major road.
4. **Drainage.** The profile and transitions at all intersections should be evaluated for their impact on drainage

**Note:**

- ① At signalized intersections, the most desirable option will be to transition all approach legs into a plane section through the intersection.
- ② Pavement transitions on the minor road from normal crown to match the slope of the major road should occur over a distance of 25'-50'.
- ③ If practical, the gradient of the approaching roadway where vehicles may store should not exceed 2%.
- ④ Actual field conditions will determine the final design.

PROFILES OF INTERSECTING ROADS**Figure 8-43**

8-10 REFERENCES

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9. Technical Council Information Report, "Design and Use of Two-Way Left-Turn Lanes," Institute of Transportation Engineers, ITE Journal, February, 1981.
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12. "Development of Guidelines for the Application of Continuous Two-Way Left-Turn Median Lanes," Final Report - EES470, Zoltan Nemeth, Ohio State University, July, 1976.
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15. NCHRP 279, "Intersection Channelization Design Guide," Transportation Research Board, November, 1985.
16. NCHRP 270, "Parameters Affecting Stopping Sight Distance," Transportation Research Board, June, 1984.